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THE PLANT LIFE OF THE BALKAN PENINSULA

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Salvia amplexicaulis Reichb. (Lam.?) (*S. villicaulis* Borb.)

Veronica teucrium L. subsp. *thracica* Vel.

THE PLANT-LIFE OF THE BALKAN PENINSULA

A Phytogeographical Study

BY

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MY WIFE

EDITOR'S PREFACE

PLANT Geography, the study of the distribution of plants and vegetation over the surface of the earth, has two kinds of interest which are largely distinct. That part of it which deals with the distribution of the species of plants as such is closely connected with the taxonomy of plants and helps to throw light on problems of the origin and relationship of species, and of higher taxonomic groups. The part which deals primarily with the distribution of types of vegetation is more closely related to the study of types of habitat—of varying climate, soil and topography—and of the effects which the nature and changes of these have upon the plant covering they carry. This latter kind of study has the widest and the most intimate bearings upon the relations of vegetation to man and of man to vegetation, the effects of each upon the other, and the problems raised by human use and abuse of the vegetation of the world. In quite recent times the exact study of the natural *succession* of vegetation, as it is called, i.e. of the plant communities which successively develop under given conditions of climate and topography and upon given kinds of soil, and of the changes in this succession brought about by man's interference, by mowing, grazing and overgrazing of grasslands, by felling, burning and pasturing in forest land, has led not only to a notable increase in the scientific knowledge of these phenomena, but to conclusions which have been successfully used as guides to the practical treatment of the vegetation.

It is neither desirable nor practicable to separate entirely the two kinds of study—the distribution of species and of vegetation—which are thus distinguished. Obviously no one can have a thorough knowledge of a particular type of vegetation— or *plant community*, as it is called—without knowing the species of which it is composed, nor can a student of species correctly appreciate the meaning of the facts of their distribution without taking into consideration their 'background', the plant communities in which they exist. But the two centres of interest are nevertheless clear and unmistakable.

In the present work the author has most happily combined the two lines of study indicated. While his primary interest is in the distribution of species, he has by no means neglected the study of the

different plant communities met with in the Balkan Peninsula, and his book is full of illumination on the effects of human activity upon the plant covering. He has analysed the composition of the floras of the different regions of the Peninsula, of the different habitats, and of the different altitudinal zones in almost every conceivable way, and much of his statistical analysis will of course be of importance mainly to special students of the subject ; but many of his chapters have a much more extensive interest.

Mr. Turrill has indeed taken the widest possible view of his topic, considering the plant world of the Balkan Peninsula as an element in the geographical history and human economy of this fascinating region, which has not only been the seat of great classical cultures, but has also for many millennia and in the most various ways served as a link between Europe and the alien world of the Near East. The Aegean Sea is dotted with islands that are the remains of a land mass which foundered in quite recent geological times, and across which plants and animals must have migrated freely. Mr. Turrill shows conclusively that the flora of the Balkan Peninsula owes a great deal to immigration from Asia Minor. His able analysis of the relations of the Balkan flora to that of the neighbouring regions of Europe, Asia and Africa, and his conclusions as to the main lines of plant migration into and out of the Peninsula, form one of the most original and valuable features of the work.

Another point of special interest about the Peninsula is the fact that while the climate and vegetation of its southern portions are typically Mediterranean, its northern borders are as typically Central European in character; and all transitions between the two types occur in the intervening country. Again, the Peninsula has been a very great manufactory of plant species, a remarkably high percentage of its flora consisting of forms confined to this region (so-called *endemic* species). Mr. Turrill suggests, with much probability, some of the causes which have contributed to this genetic activity. A very valuable analysis of the distribution of certain natural groups of plants within and without the Peninsula serves as the basis of an able criticism of Dr. Willis's doctrine of ' Age and Area '.

It is hoped that this may be the first of a series of solid contributions to the attractive and increasingly important subject of plant geography

taken in its wider sense. We have nothing in England to place beside the stately series published in Leipzig under the general title 'Die Vegetation der Erde', under the editorship of Professors Engler and Drude. One very distinguished British botanist, Dr. Leonard Cockayne, of New Zealand, found himself obliged to publish his work on that Dominion, of which a second edition has just appeared, in the German series. This is scarcely creditable to the Empire which possesses in its far-flung Dominions, Colonies and Dependencies more varied vegetation than any other political entity—vegetation, too, which is raising more and more urgent practical problems as science advances and human needs become more diverse and at the same time more insistent. If the right material is forthcoming the Oxford Memoirs of Plant Geography may serve as a valuable channel for its publication.

A. G. TANSLEY.

Magdalen College, Oxford.
November, 1928.

PREFACE

THE Nearer East has a greater significance for the history of European civilization than any other area. The influence of Judaea, Greece, and Byzantium can be traced in all the complex aspects of our modern life. The student of the past, whatever be his special subject, can never exhaust the interest of the lands surrounding the Eastern Mediterranean, for in them are to be sought the beginnings of our science, philosophy, religion, art, politics, and history. This fact is generally realized, and within the last two decades the increasing political and economic importance of these old and now rejuvenated countries has become very evident. There are, however, only a limited number of students who know that the Orient, as biologists often use the term, has a flora and fauna of unique interest.

This work is limited to a study of the seed-bearing plants (Spermatophytes or Phanerogams) of the Balkan Peninsula, whose exceptionally rich flora forms, geographically and historically, a link between the plant-life of Europe and that of Asia. It is of interest to recall that the inhabitants often refer to their Peninsula as distinct from Europe. Such phrases as 'a visit to Europe' or 'educated in Europe' are frequently used when reference is made to European countries to the north or west. This individualization of the Peninsula relative to the rest of Europe is largely artificial, and is a heritage of the long Turkish domination. The Turks, a people of Asiatic origin and modes of thought and with Oriental methods of government, never became Europeans. Yet there is also a basis of biological truth in the conception of Asiatic affinities, for not only has the plant-life, at least, more in common with that of Asia Minor and with countries farther east than any other area of Europe, but for long geological periods the Balkan Peninsula was either a peninsula of Asia and not of Europe, or was a broad isthmus joining the two continents.

The uniform use of the phrase 'Balkan Peninsula' in this work in place of the shorter and more commonly used term 'the Balkans' may seem pedantic, but it has been deliberately adopted in order to avoid ambiguities. The limits of the Balkan Peninsula, as here accepted, are stated in detail in the first chapter, and they have been rigidly adhered

to throughout the work. The term 'Balkans' has been, and is, used in many senses. 'Balkan' is a word of doubtful origin, though it is possibly Slav, and is very nearly the equivalent of the certainly Slav word 'planina' indicating a mountain range. When, with its older meaning, it is used for a concrete example, a descriptive or localizing word usually precedes it, as Kara Balkan, Catal Balkan, and Kodza Balkan. In many western European maps the east to west range separating North from South Bulgaria is frequently called 'the Balkans', though the range as a whole, with its north-western continuation, is known to the inhabitants as the Stara Planina ('the old range'). Within the Peninsula itself, and still more in central and western Europe, 'The Balkans' often implies in a rather vague way either the whole Peninsula or the parts between the Aegean and the Danube. Various other terms, such as Balkania and Europa Minor, have been used by different authors, but on the ground of general usage and convenience the phrase 'Balkan Peninsula' is preferable.

In dividing the Balkan Peninsula into districts it has been necessary to use boundaries which have no political value, though the cynic could perhaps justify the suggestion that no boundaries can be drawn within the area that have not, at some time or other, been of political significance. Politics, of course, have a wider significance in south-eastern Europe than in the British Isles! Names, whose general meaning is likely to be familiar to readers, have been applied to the districts, but when critical distributions are concerned it must be remembered that the boundaries may not exactly coincide with those assigned by existing political or popular usage.

It has sometimes been a difficult matter to decide the best spelling of the place-names. Not only have some towns, mountains, and rivers distinct names in different languages, but there is sometimes a lack of uniformity within the same language. Added to this are the difficulties of transliteration and changing political boundaries. I have followed the lists published for the Permanent Committee on Geographical Names by the Royal Geographical Society, London, or have given as alternatives the names suggested in these, but unfortunately they are far from complete. It is probable that the Slav names for the Dalmatian towns will become more widely used in the future, and though the Italian names of Ragusa, Spalato, Lesina, and so on, are at present

familiar, it is by the Slav names of Dubrovnik, Spljet (or Split), Hvar, and so on, that they are officially known. Similarly the well-known classical place-names of Ancient Greece have frequently quite different modern synonyms. Where it would appear to be useful to the reader I have given alternatives.

Apart from its unique phytogeographical importance as a link between Europe and Asia, the Balkan Peninsula offers subject-matter to students of plant-life such as cannot be found elsewhere in Europe. Geologically it has had a varied history which has resulted in a wide range of rocks and soils. Climatically it is equally varied, with the consequence that the general relations of vegetation to climatic conditions can be studied with comparative ease. It is especially the interaction of the geographical, geological, and climatic factors which makes the Balkan Peninsula so fascinating for students of plant distribution. Of still more immediate importance is the fact that there are areas of primitive vegetation, where the influence of man is negligible, and some of these are similar to the plant covering of much of Europe in pre-glacial times.

The literature dealing with the botany of the Balkan Peninsula is now considerable, but is very scattered and in many different languages. A full bibliography has been prepared, but it is impossible to include it in this work. At the end of some of the chapters and at places in the text or as foot-notes selected publications are quoted, from which special information has been derived. The earlier travellers, Tournefort, Sibthorp, Clark, d'Urville, and Grisebach, besides making valuable collections, published or left interesting accounts of the vegetation of the countries they visited. The *Flora Orientalis* of Edmond Boissier stimulated interest in the flora of the Mediterranean parts of the Peninsula and is still an indispensable work of reference. Pančić's *Flora Principatus Serbiae* and Petrović's *Flora Agri Nyssani* marked the advent of more local but relatively complete floras. These were followed by Velenovský's *Flora Bulgarica*, while Halácsy's *Prodromus Florae Graecae* is a flora of a more critical nature. The new flora of Bulgaria by Stoyanoff and Stefanoff is essential to students of plant-life in the Balkan Peninsula and Hayek's *Prodromus Florae Peninsulae Balcanicae*, when completed, will be the first attempt to deal with the flora of the whole of the Balkan Peninsula in a purely taxonomic

manner. Of vegetational studies the most important are those by G. Beck on the Illyrian lands and by Adamović on the central and northern districts (Moesia). Both of these were published in Engler and Drude's series *Die Vegetation der Erde*. In addition to the books mentioned there are hundreds of long or short papers dealing with some aspect of plant-life in the Balkan Peninsula. While these are naturally of varied values it has been essential to read them and to utilize such data as were judged valid.

My own work has been along different lines from that of my predecessors. The whole Balkan Peninsula has been taken as forming a geobotanical unit, and I have made it my aim to consider every aspect of the spermatophytic flora and vegetation that could throw light on the composition, origin, relationships, distribution, and successional changes of the plant-covering of the area. Phytogeography, or perhaps one should say geobotany, is the widest study of plant life. There is no branch of botany, one might say of natural science, which is without its influence upon the results of phytogeographical research. Our knowledge of the plants of such an area as the Balkan Peninsula is never likely to be complete, and an important function of such a survey as I have attempted is to point out the *lacunae* in our knowledge and to suggest desirable lines of future investigation. This I have done in the body of the work, and it will suffice here to point out that many of the outstanding problems can only be solved by resident botanists using modern methods. It is essential for the future that not only should the range of observations be extended but that time should be devoted to experiments.

My special interest in the Balkan Peninsula commenced at the end of 1916, when I was detailed to the British Salonika Forces. Most of 1917 was spent in Greek Macedonia, and since the war I have three times visited the Balkan Peninsula and have now seen something of most of the districts into which I have divided it in this work. The purpose underlying my studies has been to consider the plant life as constituting the flora and vegetation of a unit area with changing biological features, and which has been and is both debtor and creditor to surrounding countries. It is obvious that this could only be attempted at a large institution, where collections could be compared and correlated with the scattered literature. The Herbarium and

Library at Kew are now unrivalled in western Europe for this purpose. Moreover, from Kew it has been easy to consult the herbaria at the British Museum (Natural History), the Linnean Society, and at Oxford (Sibthorp), and the libraries in London, such as those at the British Museum (Natural History), Linnean Society, Royal Geographical Society, Air Ministry (Meteorological Office), University of London, Science Library, British Museum (Bloomsbury), and the Society for the Promotion of Hellenic Studies. Most of the taxonomic and distributional studies have been based on material now in the Kew Herbarium, to which I have presented all my own collections. I have, however, consulted herbaria in Vienna, Budapest, Belgrade, Sofia, and Trieste, in addition to others in England.

A further advantage of Kew as the head-quarters of my research has been that I have been able to study at leisure a very large number of Balkan Peninsular species in the living condition, at all seasons of the year, and in all phases of their development. In the Herbarium Experimental Ground I have made observations on the results of modified conditions on species which I had studied in their native habitats, and whose seeds I had brought or sent to Kew. There is little need to emphasize the taxonomic and phytogeographical importance of studying living plants, and my work on the Balkan Peninsular flora is being continued and extended in this direction.

An enormous amount of taxonomic work had to be undertaken before sufficient data of a satisfactory nature were available. I have already published my views on the criteria of species, and, though the application of these has frequently been limited by insufficient material, they have been applied as carefully as possible. Many experts on particular genera have helped me in difficulties.

To the Director and all my colleagues at Kew my thanks are due for helpful criticisms, and particularly to Dr. Stapf, who has taken the deepest interest in every problem. Mr. Summerhayes and Mr. Shaw have very kindly read parts of the manuscript and suggested certain improvements. I have had the constant advice of Mr. Lacey, Head of the Natural Science Department, Chelsea Polytechnic, who has not only guided me in general principles, but has helped me with many details. The officers of the Department of Botany at the Natural History Museum have afforded me every facility for consulting the valuable

collections in their charge, and with Mr. Wilmott I have had many friendly discussions on taxonomic problems. To my Bulgarian friends Prof. Stoyanoff and Mr. Stefanoff I owe an especial debt of gratitude for their unfailing help and generosity, both when I have been in their country and by correspondence. For the loan or gift of specimens and literature, and for help freely given I heartily thank: Prof. Bornmüller (Weimar), Prof. Borza (Cluj), Prof. Chodat (Geneva), Dr. Degen (Budapest), Dr. Druce (Oxford), Lt.-Col. Durham (Kew), Prof. Filarszky (Budapest), Mr. Firth (Wembley), Dr. Fritsch (Graz), Dr. Georgevitch (Belgrade), Mr. Georgieff (Sofia), Mr. Gilliat-Smith (Varna and Tabriz), Prof. Grintzescu (Bucharest), Major Harris (Canterbury), Mr. Hurst (formerly of Sofia), the late Dr. Hayek (Vienna), Mr. Jordanoff (Sofia), Mr. Kett (Gallipoli Peninsula and Cairo), Prof. Košanin (Belgrade), Mr. Lacaita (Petworth), Dr. Lorenz (Vienna), Dr. Maly (Sarajevo), Dr. Novak (Praha), Prof. Petkoff (Sofia), Prof. Podpera (Brno), Dr. Praeger (Dublin), Mr. Pugsley (Wimbledon), Mr. Salmon (Reigate), Dr. Širjaev (Brno), Dr. Stenta (Trieste), Mr. Urumoff (Sofia), Dr. Widder (Graz), Col. Wolley-Dod (Mayfield), Prof. Velenovský (Praha), and Prof. Vouk (Zagreb).

To Prof. Tansley I am deeply indebted for most valuable constructive criticism and for the very considerable trouble he has taken in arranging for the publication of this work. Not only has he spent many hours on the manuscript and proof, but in conversation and by correspondence he has given me the benefit of his wide learning and extensive experience. The imperfections in this book have certainly been reduced by Prof. Tansley's kind help and advice; the responsibility for those remaining is mine alone.

Without the unfailing help and encouragement of my wife, who has been my companion on all my later trips to the Balkan Peninsula, this work would not have been accomplished.

Grants in aid of the publication of the book have been made by the British Association, the Bentham Trustees, and the University of London. For the financial help so given I tender my best thanks.

W. B. T.

Kew, October, 1928.

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I

BOUNDARIES, GEOGRAPHICAL DIVISIONS, AND PHYSICAL FEATURES

The Balkan Peninsula projects from south-east Europe into the Mediterranean basin and, with Asia Minor, separates this from the Black Sea. It is naturally to be compared and contrasted with the Iberian and Italian peninsulas and with Asia Minor, the closest resemblances being found with the last. Unlike Spain and Italy no east and west mountain chains cut off the main mass of the land from central Europe. Geographically the Balkan Peninsula is now very obviously closely connected with the rest of Europe. Attention need only be called to the Dinaric chain, which expanding in the north broadly joins on to the Central European Alps, to the arc formed by the Stara Planina (the Balkan Mountains of many maps)—continuous, except for a narrow break at the Kasan Pass, with the southern Carpathian system (the Transylvanian Alps)—and to the Danubian plains on both sides of the river Danube in its lower course. Geologically, however, the connexion was, for long periods, with Asia Minor rather than with Europe.

Within the boundaries given below the Peninsula has a total estimated area of 187,856 square miles (480,911 km.^{2}). Very roughly the outline is triangular, with apices near Trieste, Cape Lithinos in the centre of the southern coastline of Crete, and just north of Sulina, and with irregular concave sides and a big bulge in the centre of the eastern line (Thrace).

BOUNDARIES AND GEOGRAPHICAL SUBDIVISIONS

The Balkan Peninsula is not entirely surrounded by seas and mountains, and it follows that boundaries must be partly arbitrary; but I have, for the most part, accepted those which are conventional. The southern and western boundaries (the Mediterranean and the Adriatic) call for no comment. On the north-east the natural boundary is the Black Sea, while a line through the Bosporus, the Sea of Marmara, and the Dardanelles must certainly be accepted. It is a debatable question as to where a north to south line can be most reasonably drawn through the Aegean, because the natural boundaries of the Aegean subdivisions run east and west, not north and south. I have accepted, on the basis of convenience, a line between those islands which are included in Halácsy's *Conspectus Florae Graecae* and those which are nearer to the Asiatic shore. The Thracian islands I have retained within my

boundaries on account of their geological history and geographical position. A river is not, as a rule, a floristic barrier, but the Danube and Sava form more natural boundaries than do many other rivers. It is only in the north-west that the boundary line is not marked by river, sea, or definite mountain chain. It has here been so drawn as to include the bulk of the Karst country, in order that the floristic connexions between this and karstlands farther to the south and east might be studied in detail. The Karst proper is the name applied to the tract of limestone country to the north of Trieste. With an extended meaning, the term 'karst' or 'karstland' is now used by physiographers to designate any barren and stony limestone area which is largely devoid of surface waters.

The subdivision of the Balkan Peninsula into smaller areas for the purpose of my studies has been difficult. I have examined and tested several distinct methods which appeared at first to have decided advantages over the one which I finally adopted. A subdivision on the basis of regular areas of equal size was impossible because of the very irregular outline of the Peninsula and the long and deeply indented coastline. An attempt to subdivide the country into river-basins and mountain massifs resulted in a scheme which was so largely arbitrary that it had no advantages in this respect over that finally chosen. It was moreover difficult to work with, and was an instance of 'putting the cart before the horse'. Mountains and river-basins are both barriers and highways, though to different species of plants. Finally, in drawing up the scheme, I used the following criteria:

1. The scheme must be one which can be easily worked.
2. It must be sufficiently but not too detailed for the data at present available.
3. It must be one which can be partially modified from time to time without necessitating a complete revision.
4. The scheme must not be based on any tentative theoretical conclusions regarding the influence of any single factor (altitude, climate, soil, &c.) on the flora or vegetation.

I have often found it necessary on the basis of these criteria to use present or past political boundaries, and it is worth emphasizing that many of these are most decidedly 'natural', in the sense that they mark off areas geographically distinguishable. It may also be truly, if sarcastically, remarked that political boundaries change so often in the Balkan Peninsula that there is a plenteous choice. The main objection to the scheme is that the areas are of such very different sizes. I have given the number of square miles covered by each, sometimes exactly, sometimes as nearly as possible.

Boundaries. *South.* The Mediterranean, south of Crete (including Gavdos, Guidaronisi, and Kouphonisi).

East. The Aegean Sea, following a line drawn between the Cyclades, Magnesian islands, and Thracian islands, and the islands off the coast of Asia Minor. That is, to the east of Syrina, Stampalia (Astropalia), Amorgos, Donusa, Mykonos, Tenos, Andros, Skyros, Strati, Lemnos, and Imbros, all these being included. Then the Dardanelles, the Sea of Marmara (the Marmara islands being excluded), the Bosporus, and the Black Sea northwards to the Kilia mouth of the Danube.

North. The river Danube westwards from the Kilia mouth to its junction with the river Sava, and this to its junction with the river Kulpa. The last westwards to its source, and then a line drawn across to the head of the Adriatic and including most of the Karst proper.

West. The Ionian and Adriatic Seas, the Ionian, Dalmatian, and Quarnero islands being included.

The only ill-defined portion of these boundaries is that in the north-west. It might have been better to have followed the river Sava to Ljubljana (Laibach), and to have drawn a line from there to the head of the Adriatic near Monfalcone. Much of the northern boundary is geographically and biologically artificial, this being unavoidable in the absence of any continuous east to west barrier.

Subdivisions.

1. *Crete.* 3,330 square miles.

2. *Greece.* Peninsular Greece, including also Euboea, Cerigo, the Ionian islands (except Corfu), Skyros, and other eastern islands (except those in 2a), and going north to the Othrys mountains and the Gulf of Arta. Approximately 19,000 square miles.

2a. *The Cyclades.* Andros and Kea south-east to Amorgos and Anaphe, that is, approximately to 26° E. 1,040 square miles.

3. *Thessaly.* Includes Trikkala and Larissa, the Olympus massif, and the main Pindus range. Very roughly 5,000 square miles.

4. *Epirus.* From the Gulf of Arta, 39° N., northwards to include the whole of Yannina, Arta, and Argyrokastron. Eastwards it is limited by the river Aspropotamos (Aspros or Acheloos) and the Grammos mountains. Very roughly 5,500 square miles.

4a. *Corfu*, and the smaller islets of Paxos and Antipaxos. 300 square miles.

5. *Albania.* Approximately the 1913 boundaries, except that Argyrokastron is considered to be in Epirus, and the Montenegrin 1912 boundary the northern one. From Lake Okhrida the boundary runs northwards to just west of Dibra and Prizren, across the Shar Planina, then north-west, west, and south-west across Lake Scutari to the sea. Very roughly 8,000 square miles.

6. *North (or Serbian) Macedonia*, often now called South Serbia, lies north of the 1913 frontier. On the north it follows the Bulgarian 1912 boundary (Osogovska Planina) to south of Vranje (Vranja), then an ill-defined line west to the Albanian frontier near Prizren. Approximately 11,000 square miles.

6a. *South (or Greek) Macedonia.* The Serbo–Greek frontier starts from the Albanian boundary just west of Lake Presba, runs south of Monastir, follows the Nidje and Kojuk mountains, crosses the Vardar and Lake Doiran, follows the Belasitsa Planina, and passes through the south Rodope massif to the river Mesta. It seems on the whole a fairly natural line, and I have followed it except in the north-east where my boundary bulges to the south to exclude the Rodope massif as here understood. Thasos is included. Approximately 14,000 square miles.

6b. *The Athos Peninsula*, to the canal of Xerxes. Approximately 140 square miles.

7. *Thrace.* Includes the country from the river Mesta on the west to the Black Sea on the east, and is limited on the north by the Bulgarian 1912 boundary. Approximately 10,000 square miles.

7a. *Lemnos, Imbros, and Samothrace.* 355 square miles.

8. *North Bulgaria.* With the 1912 boundaries, but including the upper valley of the Struma, and excluding the Rila Planina, Rodopes, and South Bulgaria (eastern Rumelia). 24,600 square miles.

8a. *South Bulgaria.* That is, south of the Balkan chain, but excluding the slopes of the Rodopes. Approximately 12,000 square miles.

8b. *The Rodope Massif.* Including the Rila, Pirin, Boz Dagh, Kara Balkan, Dospat Dagh, Ali Botuš, and the Rodopes proper. Approximately 7,800 square miles.

9. *The Dobruja* (Dobrogea). Taken to include the area north of the 1912 boundary, that is, approximately a line drawn from Silistria to just south of Mangalia, to the Izmail Kilia branch of the Danube. On the west it is bounded by the main stream of the Danube. 6,000 square miles.

10. *Serbia.* With the 1912 boundaries. 18,700 square miles.

10a. *The Sandjak of Novi-Pazar.* From the Serbian boundary south to the Macedonian and Albanian boundaries. Very approximately 6,000 square miles.

11. *Montenegro.* With the 1912 boundaries. 3,630 square miles.

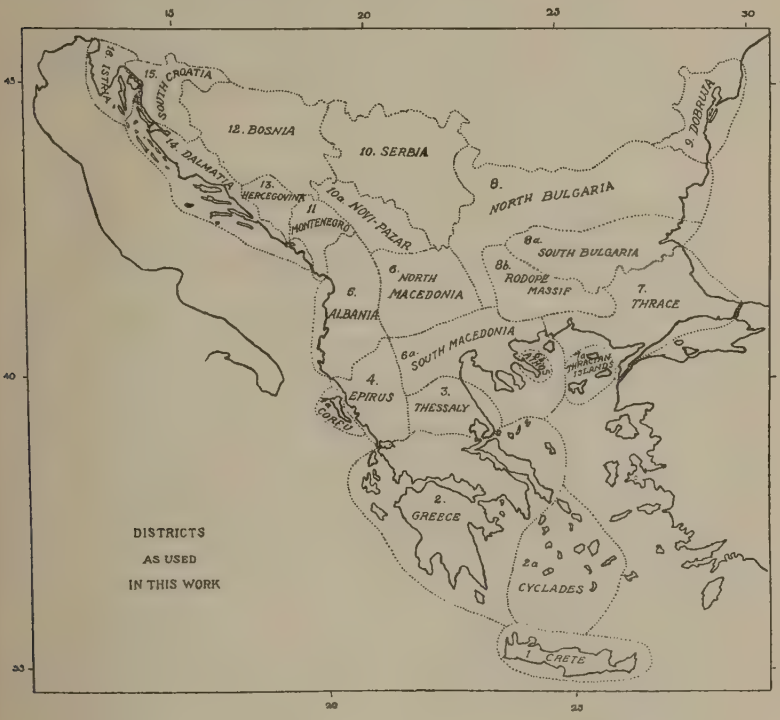
12. *Bosnia.* With the Austrian (1912) boundaries. 16,233 square miles.

13. *Hercegovina.* With the Austrian (1912) boundaries. 3,527 square miles.

14. *Dalmatia.* With the Austrian (1912) boundaries, and including the islands. 4,956 square miles.

15. *South Croatia.* With the Austrian (1912) boundaries, except that the northern limits are the rivers Sava, Kulpa, and a line across to Fiume. Approximately 4,800 square miles.

16. *Istria.* North to and including Trieste, the Littoral, the southern and south-eastern Karst, and the islands of Veglia, Cherso, and Lussin. Approximately 2,300 square miles.



The sole object in accepting the above boundaries is to obtain a standard for clearness and uniformity in quotation. Political considerations have not been allowed to intervene, and no suggestion of propaganda is to be read into anything written above. The phrase '1912 boundaries' is to be taken to indicate the boundaries *before* the 'first' Balkan War. The phrase '1913 boundaries' indicates those accepted in the treaties of London (for Albania) 1913, and Bucharest, 1913.

PHYSICAL FEATURES

Coasts, seas, and islands. The Balkan Peninsula is profoundly affected by the surrounding seas. On the west and south the Mediterranean

Sea, its branches (the Adriatic, Ionian, and Aegean seas), and the Sea of Marmara, and on the east the Black Sea (Pontic), wash the shores of its mainland and surround a large number of islands. In the Balkan Peninsula I have heard the name 'Blue Sea' given to the Adriatic, and the name 'White Sea' to the Aegean, while 'Black Sea' always refers to the Pontic. The northern Adriatic, the Ionian, and Aegean seas are very rich in islands, and the north-western and southern coasts are deeply indented. By measuring with a map measurer the coastlines and the northern boundary on Cvijić's physiographical map (1918, scale 1:3,000,000) I have obtained the following figures:

Coastline of mainland (including the Peloponnese)	6,000 km.
Coastline of islands (including Crete and Euboea)	5,100 km.
Total coastline	11,100 km.
Northern (land) boundary	1,650 km.

These figures, especially those for the islands, must be considered as only very rough.

The Mediterranean Sea is noted for its very weak tides and the blueness and the clearness of its waters. The latter is due to the small quantities of suspended matter brought into it by the rivers. Not only are the tides weak but the currents, too, are of very secondary importance, and both are almost negligible for our objects here, except in the study of the marine *Potamogetonaceae*. A chart of the chief currents of the Mediterranean, after J. Nielsen, 1913, is given by Holmboe in his *Studies on the Vegetation of Cyprus*, 325 (Bergen, 1914). The fresher surface waters of the Black Sea flow into the Aegean and assist in making good the loss by evaporation at the surface; the denser water makes its way along the bottom into the Black Sea, but is less in volume and delivery than the surface water flowing into the Aegean Sea. A similar condition obtains at the Straits of Gibraltar, but elsewhere only local surface currents, often temporary, are developed, either as drifts due to the direct action of the winds, or as streams produced by wind action heaping water up against the land; these nowhere rise to the dignity of a distinct current system, though they may obliterate the feeble tidal action. It is probable that the poverty of the pelagic fauna and flora is mainly due to the want of circulation in the depths. A great part of the bottom of the Mediterranean is covered with blue muds, and in the eastern parts these have often a calcareous or siliceous crust, from a half to three inches in thickness. The salinity of the Mediterranean is high and in the eastern basin rises to 39 per thousand, while in the Black Sea it does not exceed 20 per thousand (Murray, *The Ocean*, 55–6, no date). The peculiarities in chemical conditions of the Black Sea are worthy of note. The upper

layers, to about 125 fathoms, are normal in character and contain sufficient dissolved air to sustain life. The undercurrent from the Mediterranean can, it has been calculated, only renew the deepest layers once in 2,500 years or longer, and this rate, combined with diffusion, is insufficient to supply oxygen for aerobic organisms. The amount of atmospheric gases diminishes with increase of depth, and that of sulphuretted hydrogen increases from 33 c.c. per litre at 100 fathoms to 655 at 1,185 fathoms. The sulphuretted hydrogen is attributed to the activity of bacteria. Sulphides also appear, and increase with depth. Other chemical modifications in the deeper waters and deposits result, such as a relative diminution of sulphates and increase of carbonates, and the deposition of a powdery precipitate of calcium carbonate.

The eastern Mediterranean basin is cut off from the western by the Adventure Bank between Sicily and Cape Bon. The mean depth is about 800 fathoms. Deep water occurs near the western coasts of Greece and Crete. The steepest slope observed occurs off the island of Sapienza, near Navarino, where 1,720 fathoms has been reached only ten miles from land. The Austrian 'Pola' expeditions discovered in the 'Pola Deep', south-west of Cape Matapan, a maximum depth of 2,046 fathoms. The Adriatic Sea is shallow in its northern part, but is deeper south of a line drawn from Mount Gargano to Ragusa. North of Crete a narrow trough of deep water runs almost due east and west. The Cyclades are surrounded by shallow water, but in the northern part of the Aegean there is again a deeper trough with the Magnesian islands (Northern Sporades), Lemnos, and Imbros to the south and south-east, and the peninsulas of Kassandra, Longos, and Athos, and the island of Thasos to the north and north-west. The northern and western parts of the Black Sea are the shallowest.

Of the subdivisions adopted in this work only the following have no coastline: (6) North Macedonia, (8b) Rodope, (10) Serbia, (10a) Sandjak of Novi-Pazar, and (12) Bosnia. The districts with the most indented coastlines are (2) Greece and (6a) South Macedonia. The southern Adriatic and the Black Sea and the Marmara coasts are the least indented. Changes in the coastline, mainly due to silt deposited by rivers, since classical times, are referred to by Casson (pp. 14–16, 24–5).

The islands occur in three main groups which may be further subdivided: (1) the Aegean islands; (2) the Ionian islands; (3) the islands of the northern and central Adriatic from the Quarnero to Gruž (Gravosa). Crete (treated as a separate district in this work) and Euboea are the largest.

A very full account of the Aegean Sea and islands is given by

Philippson in *Petermanns Mitteilungen, Ergänzungsband*, xxix, Heft 134 (1901), and op. cit. xlviii, 106 (1902). It is there shown that the Aegean Sea is formed of three large basins, separated by submarine ridges or plateaux, with rows or groups of islands, which cross from Greece to Asia Minor. To the south is the island bow of Crete, to the immediate north of which lies the oldest and deepest part of the Aegean, which is bounded to the north by a submarine plateau extending from the bend of Attica and Euboea south-east and east, and carrying the Cyclades and Sporades, to Asia Minor. The central Aegean basin rarely exceeds 1,000 m. in depth, and in it arises Skyros. The ridge bounding this basin to the north carries the Magnesian islands (Northern Sporades) and the Hellespont islands (Tenedos, Imbros, Lemnos, Hagiostrati). Finally there is the long, ditch-like north Aegean basin (over 1,000 m. deep) which is separated from the Thracian coast by a broad, flat sea bottom which bears Thasos and Samothrace. The following are the chief islands of the Aegean Sea which I include in the area of the Balkan Peninsula: Crete (1); the Cyclades (2a) form a circle with Delos at about the centre, and consist of 24 larger and some 200 smaller islands. They include: Santorin (Thera), Anaphi, Milos, Kimolos, Pholegandhros (Polykandros), Sikinos, Nios (Ios), Amorgos, Heraklia, Karos, Siphnos, Antiparos (Oliardos), Paros, Naxos, Dhenousa, Seriphos, Thermia (Kythnos), Syra (Syros), Dilos (Rhenia), Mykonos, Kea (Keos), Gionra, Tinos (Tenos), and Andros; the islands associated with Greece (2) include: Cerigo, Hydra, Poros, Aigina (Aegina), Salamis, Makronisi, Euboea, Skyros, and the Magnesian islands (Skiathos, Skopelos, Khiliodhromia or Ikos, and Pelagonisi); the Thracian islands (7a) as understood here consist of Lemnos, Imbros, and Samothrace (Samothraki); Thasos is relegated to South Macedonia (6a).

The Ionian islands include: Zante (Zakynthos), Cephalonia (Kephallenia), Ithaka, Santa Maura (Leukas), Meganisi, Kalamos, Antipaxos, Paxos, and Corfu (Kerkyra). Corfu is geographically nearer to Epirus than to Greece, but is climatically distinct and has therefore been considered separately, with Paxos and Antipaxos (4a). The rest of the Ionian islands are included in Greece (2).

The Quarnero islands of Veglia (Krk), Cherso (Cres), and Lussin (Lošinj) are here included in Istria (16). Rab (Arbe), Pag (Pago), and the islands to the south of these are here considered with Dalmatia. The relationship of the Adriatic islands to the mainland is very obvious when sailing amongst them or studying them from high altitudes near the coast. They appear as higher parts of the mainland cut off by the sea invading the intervening valleys. Evidences of wholesale foundering and of more local faulting are not difficult to find. Some of the islands are only just completely surrounded by water (as Pag), while

some peninsulas are almost islands (as Pelješac, better known as Sabbioncello). South of Lussin and Pag the most important islands are: Dugi (Lunga), Korunat (Incoronata), Brač (Brazza), Hvar (Lesina), Vis (Lissa), Korčula (Curzola), Lastovo (Lagosta), and Mljet (Meleda). As will be shown later the botanical boundaries in the Quarnero do not coincide with the physiographical or political boundaries but depend on the distribution of the bora, the strong land wind from the north-east or east-north-east. A division between northern and southern Dalmatian islands can be conveniently made at Punta Planka. All the eastern Adriatic islands, south of those relegated to Istria, are included in Dalmatia (14).

Orography. In examining a contoured map, and especially one with colours for different altitudes, one is struck by the mountainous nature of the Balkan Peninsula, and travel in the country still further emphasizes the fact that low plains are mostly small and relatively isolated. Three principal mountain systems occur, but none is completely independent of the others. These are (1) the Dinaric–Albanian–Greek system, reappearing in Crete, (2) the Rodope massif, (3) the Stara-Balkan arc. In addition to these there are numerous smaller chains and massifs which either form intermediate links between the principal systems or are isolated from them. Nowhere in the Balkan Peninsula do peaks rise above 3,000 m. (9,840 ft.), and according to the latest measurements Mus Alla (2,924 m.) and the Thessalian Olympus (2,917·85 m.) have the highest summits.[1] Small patches of snow may be found at any time in the summer on the highest mountains, but there are no large permanent snowfields or glaciers now existing. The Rila Planina of the Rodope massif, forms the mountain group with the highest average altitude in the Balkan Peninsula, having twelve peaks rising up to or above 2,700 m. (8,850 ft.).

It is usual to consider the western mountains as a continuation of the south-eastern Alps. Phytogeographically it is of equal or greater importance to deal with them as running from south-east to north-west.

Crete. Four principal groups of mountains occur in Crete: in the west the Sphakia group (also known as Aspra Vouna, Madara Vuna, Madaras, and the White Mountains), with Hagion Pneuma, 2,300 m. and Hagios Theodoros, 2,410 m. (also given by Rikli as 2,469 m.); in the centre the Psiloriti, with Ida, 2,457 m. (also given as 2,498 m.); towards the east the Lassiti, with Aphendi Kristos, 2,155 m.; and still farther east the Sitia group, with Aphendi Kavutsi (Aphenti Vouno),

[1] In giving altitudes I have consulted the best authorities and most recent surveys available. Unfortunately the figures given in many maps are unreliable. Sometimes they appear to be mere guesses, as I have personally experienced in the Rodopes.

1,472 m. A short line of mountains with the peak Kophina, 1,143 m., runs along the centre of the south coast, and between this and the central chains (Psiloriti) is the plain of Messara, the largest in the island. Most of the rivers are short and run north or south from the mountain backbone to the sea, excepting the Mitropoli and the Anapodiari, which drain the Messara plain. An interesting feature is presented by the level upland basins, which furnish abundant summer pasturage. These include the Omalo in the Sphakia group, 1,100 m.; Nida in the Psiloriti, 1,500 m.; and the Lassiti plain, 900 m. Numerous deep, narrow, dark ravines, bordered by precipitous cliffs, are characteristic of the mountainous districts.

Greece, Thessaly, and Epirus. The Peloponnese (Morea) is naturally almost an island, being joined to the rest of Greece only by the narrow Isthmus of Corinth. From the southernmost point, Cape Matapan, a range of mountains, Taygetos or Pentadactyli, runs approximately northwards and includes the peak Hagios Elias, 2,400 m. To the east of this range is the fertile valley of the Eurotas with Sparta, and beyond is the range of Parnon (Malevo), discontinuously increasing in importance from Cape Malea northwards, and rising to 1,940 m. The mountains of western Messenia are more irregular and mostly lower. In the centre of the Peloponnese is the plain of Tripolis (Tripolitza) and to the north the Mainalon (Hagios Elias), 1,981 m. In the northern very mountainous parts a considerable number of important peaks occur, including Skipiesa (Oliertus), 1,930 m., Onion, 1,580 m., Kyllene (Ziria), 2,374 m., Chelmos (Aroania), 2,355 m., Olenos (Erymanthos), 2,214 m., and Panachaicon (Voidia), 1,927 m. The north-eastern part is lower.

Beyond the Gulf and Isthmus of Corinth the orography becomes even more complex. In the broadest part of the isthmus occurs Geranion, 1,370 m., and in the Attic peninsula the famous mountains Hymettus, 1,027 m., Pentelicon, 1,100 m., and Parnes (Ozea), 1,313 m. Farther west we come to Pateras, 1,092 m., Cithaeron (Elatias), 1,411 m., Helicon (Palaio Vouno), 1,749 m., and Parnassus (Lyakoura), 2,459 m. The south-eastern parts of Attica are mostly plains and low hills, while north and north-east of the mountains last mentioned lies the Boeotian plain with Thebes and Lake Copais, the latter now nearly drained. The island of Euboea is 100 miles long and has a maximum breadth of 30 miles. It is mostly a confused mass of low hills with fertile valleys between, but near the centre is Dirphys (Delphi), 1,745 m., and south of this Olympos, 1,175 m., while in the extreme south-east Hagios Elias (Ocha) rises to 1,475 m. Along the west coast run the mountains of Kandili and the Drakospelio, and between the latter and Dirphys lies the basin of Gides, a great, level plain about 215 m.

above sea level. None of the Cyclades reaches above 1,000 m. To the north of Euboea, near the Thessalian coast, are the isolated groups of Pelion (Plessidi), 1,618 m., and Ossa, 1,955 m. Beyond the Thessalian plain lies the Olympus massif whose highest peak has now been carefully determined as 2,917·85 m. The fertile plain of Thessaly is bounded on the north by the Khassia mountains (with Mitritza, 1,347 m., and Phlamburo, 1,207 m.) and the Olympus massif, on the west by the Pindus range, on the south by the Othrys mountains (to 1,728 m.), and on the east it is cut off from the sea by Ossa and Pelion. It is divided into two parts, the plains of Trikkala and Larissa, by a long spur of low cultivated hills which run south-eastward from the Khassia mountains. South of the Othrys mountains lies the plain of Lamia. Returning to the northern side of the Gulf of Corinth, to the west of Parnassus we come to the southern parts of the Pindus range, which occupies with its subsidiaries most of Aetolia, eastern Epirus, and the western parts of Thessaly, and stretches northwards to Macedonia. Of the very many high peaks in the southern branches of the Pindus the following are of special importance to us: Kiona (Ghiona), 2,512 m., Korax, 2,352 m., Vardusia, 2,495 m., Oeta (Katavothra), 2,152 m., Oxya, 1,927 m., Kaliakuda, 2,104 m., and Tymphrestus (Veluchi), 2,319 m. To the west of these high peaks and groups the country is mountainous, but the altitudes are lower. Northwards in the Pindus proper are the high peaks of Butsikaki, 2,156 m., Karava, 2,124 m., Tsumerka, 2,336 m., Strungula, 2,018 m., Kakardista, 2,320 m., Peristeri, 2,290 m., and Smolika, 2,570 m. The country to the north of the Gulf of Arta is low and swampy, and there are other alluvial plains of which that of Yannina is the chief. Apart from these most of Epirus is hilly and mountainous but without high peaks. The numerous mountains (mostly of limestone) appear either as gently undulating plateaux or as long, extended ridges which seldom possess pronounced summits. None of the Ionian islands reaches a very high altitude, but from their position the principal peaks have a marked effect on precipitation. In Corfu, Pantokrator (San Salvatore) reaches 911 m.; Meganoros in Leucas, 1,036 m., Elati, 1,159 m., Stavrotas, 1,180 m.; Aenos in Cephalonia, 1,036 m.; Gyri in Zante, 736 m.

Albania, Montenegro, and Dalmatia. North of the area already dealt with in this section lies the more continental part of the Balkan Peninsula. The Pindus range is continued north of Smolika as the Grammos, a little to the north-west of which is Mavri Petri, 2,536 m. The Albanian mountain system is conveniently considered as bounded on the east by the Black Drin and the Okhrida basin. In the south-west the Chike Dagh (Khimara) skirts the coast and runs out into the lofty promontory of Vasilios (Acroceraunia) terminating in the Maj'é Ghuhes (Cape

Glossa or Linguetta). Inland to the north-east of this the Tomor range reaches to 2,413 m. To the west of Tomor the peak Kamne reaches 2,150 m., and to the north-west of Lake Okhrida, the Jablanitse (Yablanitsa) range is said to reach 2,312 m.

The whole of the centre of Albania consists of hills and mountains, with a main north and south trend, but the contouring and altitudinal measurements given in published maps are mostly unreliable in their details. The coast is generally low, swampy, and unhealthy. In the north-east the Shar Planina (Scardus) crosses from Albania into North Macedonia. Its two principal peaks are Kobelica in the west, 2,370 m., and Ljubatrin (Ljubitrn, Ljuboten), 2,510 m., in the east. Just to the south of the western end of the Shar Dagh is the important range of Korab, 2,050 m., and to the north the mass of Koritnik, 2,300 m. The 'North Albanian Alps' and the mountains of Montenegro form a huge agglomeration of high mountains running mainly east and west in the southern part, and passing into the main Dinaric chains to the north. Of the numerous high groups and peaks the following have been important botanical collecting areas: Maja Eršalit, 2,150 m., Kakinja, 2,310 m., Maja Drenit, 2,140m., Galica Lums, 2,150 m., Kom, 2,448 m., Hum, 1,832 m., Maganik, 2,108 m., Sto, 2,258 m., Sinjavina, 2,160 m., Lovćen, 1,759 m., Vojnik, 1,999 m., Durmitor, 2,588 m., Volujak, 2,400 m., and Maglič, 2,389 m. On the borders of Montenegro and Hercegovina is Orjen, 1,895 m. A narrow coastal belt and the area around the Lake of Scutari are the only lowlands, apart from small river valleys in Montenegro and Dalmatia south of the peninsula of Sabbioncello. Three groups of high ground may be distinguished in Dalmatia. Firstly, the mountain chain of the Dinarics (Troglav, 1,913 m. and Dinara, 1,831 m.), joining in the north to the Velebits. Secondly, an intermediate line of hills, arranged generally in groups, enclosing small plains. Thirdly, the littoral line of hills running along the coast. The numerous islands and island rows, for the most part parallel to the coast, have the appearance of being another partly submerged line of hills, of which only the summits project above the surface of the sea. Lowlands, often swampy and infested with mosquitoes carrying malaria, occur in association with the lower course of the Narenta and the Cetina, and from Sebenico to north of Zara the lower coastal stretch is wider, but, with the few exceptions already mentioned, from Sebenico to the Bocche di Cattaro the coast is in most places flanked by steep hills and mountains.

Bosnia and Hercegovina. Most of the mountains of Bosnia and Hercegovina are of limestone and many exhibit karst phenomena. In part they are portions or offshoots of the Dinaric system, and in part they form with the western Serbian mountains transitions to the more

eastern and southern groups. The following are botanically known to be of importance: Troglav, 1,415 m., Lubjcna, 2,236 m., Treskavica, 2,083 m., Bjelasnica, 2,067 m., Visočica, 1,964 m., Prenj, 2,102 m., Čvrstnica, 2,228 m., Vranj, 2,074 m., Čabulja (Cabolja), 1,769 m., Velez, 1,969 m., Vratnica, 2,107 m., Vlasić, 1,919 m., and Sator, 1,872 m. To the north the Dalmatian and Bosnian mountains pass into the Velebit, with peaks up to 1,758 m., and the Pljesevitza, to 1,649 m. The latter to the north pass into the Kapella mountains, with altitudes up to 1,533 m. Much of Istria is high karst plateau country, rising in Mount Maggiore to 1,396 m.

Rodope Massif. The Rodopes, and associated chains and groups, comprising what in this work is referred to as the Rodope massif, form the true core of the Balkan Peninsula. Their true limits, especially towards the south and east, are difficult to define. The lower hills and mountains of the Arda watershed have a few peaks of importance: Kuschlar Dagh, 2,180 m., Perlik (Karlak), 2,190 m., and Karlik (Kartal) Dagh, 1,500 m. Unfortunately very little is known botanically of this most interesting district. In the west Rodope are the considerable peaks of Batak, 2,072 m., Sitke (Sjutke), 2,187 m., and Belmeken, 2,647 m. The Rila forms the highest mountain mass of the Rodope system and of the Balkan Peninsula. According to Cvijić the Rila has 134 km². of ground between 2,400 and 2,700 m., and more than 6 km². between 2,700 and 2,924 m. The highest peaks are Mus Alla, 2,924 m., Manču, 2,780 m., Čador Tepe, 2,778 m., and Juruški Čal, 2,773 m. As southern and more or less separated extensions of this high group are considered the Pirin Planina, rising up to 2,681 m., and, still farther south, Ali Botuš, about 2,100 m.

Stara Planina. The main chain of the 'Balkan' range (Stara Planina of the Bulgarians, and the Haemus or Haimos of classical authors) runs nearly due west from the Black Sea between Burgas and Varna to north of Sofia. Here it bends to the north, and is then marked in most western European maps as the Stara Planina. Farther to the north the chain is more broken and the peaks are lower, but the continuation to the Danube at the Kasan Pass near Orsova, and the Iron Gates, and the junction, broken only by the river, with the Carpathian system (Transylvanian Alps) can be traced. The following are the names given to different parts of the chain, commencing from the east: Emine and Aitos Balkans, Karnabat, Devent and Kodza Balkans, Kotel Balkan to 1,045 m., Ičerinski Balkan, Sliven (Deve) Balkan with Smiti Kamen, 1,182 m., Veliki (Tvrdica and Venceti) or Kodža Balkan with Čumerna, 1,535 m., Šipka Pass, 1,333 m., Trojan Pass, 1,502 m., Mazalat, 2,278 m., Jumrukčal, 2,385 m., Mara Gidik, 2,374 m., Ambarica, 2,166 m., Kadimlija, 2,272 m., and Kopen, 2,147 m., Vežen and Teteven

Balkans, up to 2,200 m., Zlatica Balkan, Etropol Balkan with Murgaš, 1,695 m., Lakotnik Balkan. West of the Isker the Stara Planina has the following high peaks: Kom, 1,969 m., Kopren (Dabidžin Vrh), 2,115 m., Tri Čuke, 2,032 m., Vražija Glava, 2,026 m., Golema Čuka, 2,014 m., Martinova Čuka, 2,059 m., and Midžur, 2,186 m. Following Bulgarian usage the Stara Planina in this work refers to the whole chain. The Srednja Gora and the Surnena Gora form a parallel chain to the Balkans with the Banja and Kazanlik valleys between.

Macedonia, Novi-Pazar, and Serbia. The mountains of Macedonia, the Sandjak of Novi-Pazar, and Serbia largely form transitions between the Rodope and Stara Planina groups to the east and the Dinaric system to the west. The Krusa Balkan and the Belasitsa (up to 1,808 m.) in South Macedonia run approximately east and west, and the latter with the Kojuk (to 2,180 m.) and Nidže (to 2,525 m.) mountains, to the west of the Vardar, form the northern boundary of South Macedonia. Peristeri, to the east of Lake Prespa, is 2,530 m., and the Galitchitsa, 2,043 m., between Lakes Prespa and Okhrida, along with the Kara Orman, 2,145 m., probably belong to the Albanian system. In the east of Macedonia the Osogovska Planina reaches to 2,104 m., and is probably related to the Rila. The Suva Planina, 1,822 m., in eastern Serbia is related to the Stara Planina system. The Karadjitse chain rises to 2,530 m., between Prilep and Skoplje (Üsküb). The Kopaonik, east of Novi-Pazar, attains 2,140 m., and the Golija, to the west of this, 1,842 m. West of Nish the Jastrebatz reaches 1,565 m. In north-east Serbia numerous lower hills and ranges serve to link the Stara Planina and Carpathians. These include the Miroč, Crni Vrh, and Rtanj mountains. In western Serbia the Tara, Zlatibor, Murtenica, Mučanj, and Dragačevo mountains are rather part of the Dinaric system. In the centre of Serbia the Povlen, Rudnik, and Crni Vrh mountains are transitional.

Eastern mountains. Mention must be made of the Strandja mountains which form an isolated system running from south-eastern Bulgaria into eastern Thrace and cutting off the basin of the Ergene Su from the Black Sea. They reach (in Thrace) to an altitude of 1,031 m., and though low are of great phytogeographical interest. The mountains between the Babadagh and Mačin in the Dobruja are another isolated group, with peaks up to 431 m. They have no connexion with the Carpathians and Balkans, but appear to represent the remnants of old mountains perhaps geologically connected with the Crimean and Caucasian mountains.

Plains. In the central and eastern parts of the Balkan Peninsula the plains deserve separate mention. In South Macedonia a considerable area of lowland occurs around the lower courses of the Bistrica, Vardar,

and Galik rivers. In northern Macedonia there is the inland plain of Monastir (Bitolj), the basin of Skoplje (Üsküb)–Kumanovo, and the Kosovo Polje. The plain of Strumitsa is almost surrounded by mountains of a considerable height, while the Struma plain on the east joins on to the low coastal land of Thrace, which forms a band of varying width between the Rodopes and the Aegean Sea. In eastern Thrace there is the extensive lowland of the Ergene–Lower Maritsa basin, and this extends east to Constantinople with only minor interruptions. Much of South Bulgaria is the plain of the Upper Maritsa which is separated by hills from the lowland round Burgas. The Preslav–Varna plain is separated from the Danube area by the higher ground of the Deli Orman, while the Sofia and Kazanlik basins are quite enclosed. The northern parts of North Bulgaria and most of the Dobruja belong to the Lower Danube plain, which is continued on the other side of the river into Roumania.

Hydrography. The river systems of the Balkan Peninsula are interesting from every point of view, and are of particular importance to the botanist because the inland extension of Mediterranean species is mainly up the river valleys. We may consider first those rivers which drain into the Adriatic and Ionian seas, secondly those which drain into the Aegean Sea, thirdly those which drain directly into the Black Sea, and lastly the Danube system.

The rivers draining into the Adriatic Sea are, with few exceptions, short and unimportant. This is partly due to the mountain ranges running for the most part parallel to and near the coast, partly to the limestone karst nature of the land and the big development of subterranean drainage systems. The Cetina in northern Dalmatia drains an intermontane valley practically parallel with the coast. The Narenta drains a fair area in Hercegovina, and the existence of its valley, at right angles to the coast, is one of the reasons why so many Mediterranean species occur in Hercegovina. The Zeta drains into Lake Scutari, which, with the Drin (Drim) formed by the union of the Black and White Drins, is connected by the Boyana with the Adriatic. The Albanian rivers, Matje, Arzén, Shkumbi (Skumba), Semen, and Viosé (Vojusa), drain direct to the low coasts, but are all relatively unimportant. The Arta (Arachchos) and Aspropotamos (Acheloos), both draining approximately from north to south, are the chief rivers entering the Ionian Sea. The Rouphras (Alpheris) and the Euratos are the largest rivers of the Peloponnese. A number of important rivers discharge into the Aegean Sea. The Peneios (Salamyria) drains the Thessalian plain and pierces the coastal mountain system in the pass of Tempe. The Bistrica has a very narrow valley and no important tributaries. The Vardar and its tributaries penetrate far into the Peninsula

and are only separated from the Danubian (Morava) system by relatively low watersheds. The Vardar–Morava route is one of the three[1] most important in the Balkan Peninsula. The Struma rises in the Vitoša in Bulgaria and enters the Gulf of Orphano, but has few large tributaries; while the Mesta has a much shorter course. Excluding the Danube system, the Maritsa basin is the largest in the Balkan Peninsula. The streams draining from the north-east of the Rila and the Sredna Gora combine to form the Upper Maritsa, which runs from west to east in South Bulgaria. At Adrianople it is joined by the Tundza and the main stream then runs from north to south. The Lower Maritsa is joined by the Ergene, which drains much of eastern Thrace. Both the Tundza and the Maritsa show examples of river capture.

No rivers of importance enter the Marmara Sea from the Balkan Peninsula, and only the small streams of Kamčija and Provadija are worth mentioning as draining into the Black Sea south of the Danube delta.

The Danube is the mightiest river of the Balkan Peninsula, and its system drains about one-third of the entire area. Commencing from the west the Kulpa joins the Sava whose chief right-bank tributaries are the Una, Vrbas, Bosna, and Drina. At Belgrade the Sava unites with the main stream of the Danube, whose chief right-bank tributaries after this are the Morava (with the tributaries of the Serbian Morava and Nishava), Timok, Isker, Vid, Osma, and Jantra. The double change of direction of the main stream in the Dobruja, and the delta with the three mouths, Kilia, Sulina, and St. George, are to be noted.

While the Pindus, parts of the Dinaric system, and the Stara Planina form important watersheds, it must be noted that these are often complex, and are cut into in various directions and to various degrees, and sometimes are even cut right across (as by the Isker). The relative unimportance of the Rodope–Rila mountains as a watershed is of interest, for it is the Vitoša which helps to separate the Aegean Struma from the Danubian Isker.

Many of the lakes of the Balkan Peninsula are of interest because they are the remnants of larger bodies of water, which at an earlier geological period were part of the Pontic or Sarmatian water systems. The following are the chief: Phonia in the northern Peloponnese; Copais in Boeotia, now much reduced by drainage; Trichonis (Agrinion) in Acarnania and Aetolia; Karla in Thessaly; Yannina (Joannina

[1] The other two are the Belgrade–Nish–Sofia–Adrianople–Constantinople and the Constantinople–Salonika–Monastir–Elbassan–Durazzo routes. The latter is the old 'Egnatian Way.'

or Janina) in Epirus; Kastoria, Vendrok (Malo Jesero), Prespa, Okhrida, Ostrovo, Ardzan, Amatovo, Doiran, Langaza, Beshik, Tahinos (Tachynos), in South Macedonia and on the borders of North and South Macedonia; Gala (Jala) in Thrace; Scutari between Albania and Montenegro; Vrana in northern Dalmatia; the Plitvica in southern Croatia; and Djevna near Varna in eastern Bulgaria.

Volcanoes and earthquakes. A few brief remarks must be made on the volcanic and seismic activities still prevalent in parts of the Balkan Peninsula. There are no active volcanoes on the mainland, but Santorin, in the southern Cyclades, has erupted as recently as 1925. In Greece there are many traces of geologically recent volcanic and seismic actions. There is an extinct crater at Mount Laphystium (Granitsa) in Boeotia. The mountain of Methane, on the coast of Argolis, was produced by a volcanic eruption in 282 B.C. There are hot springs at Thermopylae and other places. Earthquakes are of frequent occurrence in southern Greece. Thebes was laid in ruins in 1853, every house in Corinth was destroyed in 1858, the Castalian spring was filled in 1870, Zante was devastated in 1893, and the district of Atlanta in 1894. A severe earthquake caused much damage in south-eastern Cephalonia and the north of Zante, and disturbed nearly all Greece, in January 1912. After-shocks continued for several months. For the fourth time in sixty-two years Thebes was seriously damaged by an earthquake on October 17, 1914. 712 after-shocks occurred here within a year. In November 1914 and January 1915 two destructive earthquakes occurred in the Ionian islands.

The island group of Santorin (Thera) has often been described. An excellent account is given by Tozer, *The Islands of the Aegean*, ch. V (London, 1890). The principal historical eruptions occurred in B.C. 196, A.D. 726, 1573, 1650, 1707, 1866, and 1925. An account of the last will be found in *The Times* for August 14, 1925.

Earthquakes and hot springs are frequent in many other districts of the Balkan Peninsula, especially in areas showing signs of recent faulting (as parts of Dalmatia), or of geologically recent folding. Many thermal springs have a considerable reputation for their supposed medicinal value. *The Times* for February 15, 1927, records a severe earthquake in southern Dalmatia and the Hercegovina, with its epicentre between Ragusa (Dubrovnik) and Lyubinye (Ljubinje). Many earthquakes are recorded in the history of the Ragusan Republic. Disastrous earthquakes have recently occurred in the Aegean area, at Corinth, and in South Bulgaria (see *The Times* for April 2, 16, 17, 20, 21, 23, 24, 26, and 28, 1928).

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II

GEOLOGY AND SOILS

THERE are two aspects of the geology of the Balkan Peninsula which concern us in the present studies: the history of the country in so far as it has affected the distribution of floras and species, and the rocks as the basis of soil formation. It is impossible to deal effectively with these aspects or to realize the essential features of the existing physiography without considering some details not directly applicable to our work. We need not attempt to summarize the geological history previous to the appearance of Angiosperms, and indeed it is mainly the later Tertiary and Quaternary times which call for attention. A *résumé* of the basic geological structure of the Balkan Peninsula will be given first, then accounts of the transmigrations and regressions of the sea, of the main tectonic movements, of the surface rocks and soils, and lastly a brief summary of the chief geological features of the individual areas.

GENERAL STRUCTURE AND HISTORY

The core of the Peninsula. The centre of the Balkan Peninsula is occupied by a core of ancient, hard, resistant rocks, igneous and metamorphic. The name 'Rodope Massif' has been applied to this core, which is analogous to the old massifs of the Scottish mountains, the central plateaux of France and of Czecho-Slovakia, the Spanish meseta, and the Lydian-Carian massif of Asia Minor. The Rodope massif is roughly triangular in shape, with its apex near Belgrade and its base stretching from the Black Sea to the Aegean. In places it is obviously overlain by younger beds, but these are often of lacustrine origin, and after a fairly extensive series of field observations in various parts of the Rodope massif and a very careful reading of all available published research on the question, I have been forced to the conclusion that this mass has been essentially continental throughout Tertiary and Quaternary times at least, and probably also through much of the Mesozoic epoch. Not only is there the negative evidence of the absence of marine sediments but the positive evidence of Neogene freshwater deposits. Its margins have been frequently invaded, especially in Sarmatian and Pontic times, while Mesozoic and Tertiary deposits were laid down all around it. In spite of the theoretical views now in vogue regarding the origin of mountains and the floating movements of continents and continental masses, the field evidence for the mid-Tertiary appearance of the Rodope mass appears very weak. Around

this Rodope massif to the north and to the west are the folded mountains of the Stara Planina, the Dinaric Alps, and the Albanian–Greek mountains. These are essentially composed of sedimentary rocks, especially of limestones, which are of various ages from Triassic to Neogene. Whether these mountains have been formed by vertical upheaval or by lateral compression need not concern us here. They undoubtedly have a close relationship to the core. As the southern Carpathians are traced westwards they appear to come into contact with the old mass and to bend round finally to a west and east direction. On the other side the Dinaric Alps and associated systems run down from north-north-west to south-south-east to the region of the Drin Gulf. Here there is a sudden change of direction, and in northern Albania the lines of mountains are first east and west, then north-east to south-west, and later north and south. This north and south direction is retained by the Greek mountains, except for eastern offshoots, and it is only in Crete that we find again a west and east direction, which is continued beyond to southern Asia Minor and perhaps farther. These mountains belong to the same general Tertiary mountain formation as the Alps, and indeed the general east and west mountain system of southern Eurasia from the Pyrenees to the Himalayas. Their age is not quite the same in all parts, but the folding became evident in Oligocene times, reached a maximum in the Miocene, and was continued into the Pliocene.

Transgressions of the Mediterranean. We have now to consider in some detail these sedimentary beds and the geological history indicated by them. The Mediterranean Sea is one of the oldest and most permanent of sea-basins, and yet one which shows enormous local changes. It will be accurate and convenient to base a summary on the changes of the Mediterranean and associated seas relative to the Rodope massif—the core of the Peninsula. While Palaeozoic rocks occur within the area they are of relatively slight importance. Triassic rocks outcrop, especially to the north-east in the area of the Dinaric Alps. Cretaceous beds have a very large outcrop on all sides of the Rodope mass. Especially characteristic are the Hippurites limestones (Rudistenkalk). The *Rudistae* were probably shallow-water organisms, and though during much of the Cretaceous a very large proportion of the Peninsula must have been under the sea (the Rodope area forming an island or a series of islands), this was not of great depth in many parts. In Istria and Dalmatia the Hippurites beds are frequently immediately overlain by fresh-water beds. In addition to the Hippurites limestones, there is a great development, especially on the west, of 'flysch', the name being given especially to arenaceous beds partly of Cretaceous age. To the north the Cretaceous Sea was limited by a large central European island. The Alps, of course, were not in existence, but the northern

part of the Dobruja was dry land as it has continued to be ever since, and parts, at least, of the Carpathian mountain bow appeared above the sea in Cretaceous times.

During the Eocene we again find a great transgression of the sea, in which were deposited massive nummulitic limestones and sandy beds which are also designated 'flysch'. Oligocene beds are represented, but are of secondary importance.

From Miocene times onwards the transgressions and regressions of the sea have a special importance for this work. Moreover, the phases are distinct from those of western Europe, where names were first applied to strata of different ages, and it will be best to follow the nomenclature of Suess, and to give a table indicating the probable correlation of the beds. It is necessary again to emphasize that though the seas of the periods now under survey frequently penetrated far into the Balkan Peninsula there is no evidence that they entirely covered it at any one time. It is certain that large land areas were always in existence, of which the most constant was the 'Rodope Massif'.

Deposits of the first Mediterranean stage, to use Suess's term for the Middle Miocene, are lacking in our area, including the Archipelago, as they are on the edges of the Black Sea. It is important to note, however, that the sea penetrated far inland in central Europe, up to Czecho-Slovakia, and that its beds are found again from southern Asia Minor to Persia. At this time the Balkan Peninsula was a peninsula of western Asia, not of southern Europe. The 'Schlier', saline grey and marly beds interpolated between the first and second Mediterranean stages, are also not met with in our area. The nucleus of the Alps was appearing at this time, and the intra-alpine basin of Vienna was formed, separating the Alps from the Carpathians. The Schlier represents a vast expiring sea, but a new great invasion led to the deposition of beds of the second Mediterranean stage. The sea penetrated up the Morava valley of Serbia and into northern Bulgaria, but on the periphery of the Black Sea littoral, of the Sea of Marmara, and the Aegean, and in all the central parts of the Balkan Peninsula deposits of this stage are unknown, just as are those of the first stage, though they are found in Crete, southern Asia Minor, and farther to the east. A branch extended far to the north of the Balkan Peninsula, surrounding the Carpathians and advancing far across South Russia. At this stage the Alps were considerably raised, and by now the first junction of the Balkan Peninsula with Europe had occurred to the north-west.

Above the second Mediterranean stage in east Central Europe is a series of marine beds with a poor but very uniform fauna. These beds, termed Sarmatic, extend from the west of Vienna into the Pannonian plain and to the boundaries of Transylvania. They appear on the

northern edge of the Bosnian mountains and again in the Banat. The stage is widespread in Wallachia and North Bulgaria, but the Stara Planina limits them to the south, though they extend east to Varna. They are traceable to the Sea of Marmara but do not penetrate into the basin of Adrianople. They form the greatest part of the peninsula of Gallipoli, making horizontal beds on both sides of the Dardanelles up to about 244 m. above sea level. They are also evident near Constantinople. They are not known south of the Troad nor definitely across the Aegean Sea. In the north they extend to southern Poland, Galicia, Podolia, and Bessarabia, and eastwards to southern Russia. They occur in the Crimea and Caucasus and have been traced to the south of the Caspian up to the Aral Sea. Thus the Sarmatic Sea was a vast sheet of salt water penetrating into and extending far to the north and east of the Balkan Peninsula, and effectively cutting off communication with Central Europe except by way of the Alps.

Succeeding the Sarmatic deposits in many areas are extensive beds laid down in fresh or slightly brackish water. This stage is best termed the Pontic. The basins of Pannonia and Vienna were covered by this great lake, which penetrated eastwards over South Russia (depositing the steppe limestone) in the direction of the Caspian, south-westwards into the basin of Adrianople and the coast of Khalkidikē, and even to eastern Thessaly. Pontic beds are thus recognized in all the valleys of the Middle and Lower Danube and in much of the Pontic region. Even in Italy on the sides of the Apennines, and in the Rhone valley, beds of a similar type occur. The Sarmatic and Pontic beds undoubtedly represent a great regression of the sea, and the Mediterranean proper probably did not extend east of Corsica and Sardinia. For this reason neither the Sarmatic nor Pontic beds are included as stages of the Mediterranean.

After the Pontic phase the sea enlarged again and covered with fresh marine beds a great part of the region of the Pontic deposits. This is the third Mediterranean stage. Strata of this age are entirely lacking in the northern part of the Adriatic area; in the interior of the limestone chains of the mountains of Dalmatia they are replaced by freshwater deposits. They occur at Dulcigno and in the Ionian islands, and form a great band round the Peloponnese. In the Aegean area, Cyclades, Euboea, and north of Imbros and Lemnos there was a deep freshwater lake, or most probably a series of lakes, in which were laid down massive lacustrine deposits which Spratt termed Levantine. No marine beds of the age are known in the Danube valley or in the Black Sea region, but freshwater 'Levantine' beds with numerous marsh deposits have been recognized in Dalmatia, Bosnia, northern Greece, Crete, and Asia Minor.

Beds of the fourth Mediterranean stage penetrate into the southern Cyclades, but the Aegean area was still land, and the Balkan Peninsula an isthmus joining Europe and Asia and separating the Black and Mediterranean Seas. This continental isthmus first foundered in its southern part, up to Milo, Rhodes, and Cos, where marine deposits of the fourth Mediterranean stage rest on the freshwater Levantine beds. The still active volcanic line of the Cyclades (Santorin, &c.) marks the line of fractures. Lastly, probably slowly, all the Aegean continent foundered, and massive Levantine lacustrine deposits, often forming horizontally banded cliffs, marked the new shores of the advancing Mediterranean. Many of the valleys of the Balkan Peninsula were penetrated by the Sarmatic and Pontic waters, and as evidence of tectonic movements one often finds their deposits now at considerable altitudes. Perhaps some of the drying-up lakes, as Tahinos, are remnants of the Pontic phase.

The forming of the Aegean Sea and the joining of the Mediterranean and Black Seas by the old river-valley of the Bosporus and Dardanelles altered the drainage system of the Balkan Peninsula and was a cause, together with other tectonic movements, of the 'young' topography of many areas around the Aegean Sea.

We may note then as being of great importance for our subject that:

1. Throughout the Tertiary epoch the Balkan Peninsula was either a peninsula of Asia or an isthmus joining Europe and Asia, there being always a considerable area of dry land.

2. The first connexion with Europe was in the north-west corner, and with the young Alps. A probable early connexion with the Carpathians, forming an isthmus or a peninsula or a string of islands, must, however, not be forgotten.

3. During the Sarmatic and Pontic periods a sea or (later) a great lake spread over the plains and basins to the north of the Balkan Peninsula and cut off the southern land from the lowlands of central and northern Europe.

The following table synchronizes Suess's nomenclature with that in more general use:

5th Mediterranean stage.	Recent.
4th Mediterranean stage.	Quaternary.
3rd Mediterranean stage.	Pliocene.
Pontic stage.	
Sarmatic stage.	Upper Miocene.
2nd Mediterranean stage.	
Schlier.	Middle Miocene.
1st Mediterranean stage.	

Suess considered the Pontic beds to represent the top of the Miocene,

while Zittel, Philippson, and others have placed them at the base of the Pliocene.

Relationships with Italy. The relationships of the Balkan Peninsula to the Italian Peninsula must be briefly considered. Italy is geologically the youngest of the great Mediterranean peninsulas. A relatively small area in the north-west is a remnant of the old Tyrrhenian continent, and in the south-east metamorphic crystalline rocks occur. Apart from these areas the mass of the peninsula owes its origin to the great Tertiary alpine folding or upheaval. The Apennine area was for a long period in the Tertiary either an island or a peninsula of the Alps. The origin of the existing Adriatic Sea has been much discussed. The older view is that it was formed by faulting and foundering and the inrush of the sea, probably in two or more distinct stages, approximately at the period of the Aegean formation, that is, in the fourth Mediterranean stage. This view has been disputed by Nowak, who considers the area to represent a geosyncline which is causally bound up with the folding of the Apennines and Dinarics. On the latter view the sea would be much older than has generally been thought.

Tectonics. The Balkan Peninsula has been an area of great tectonic movements, continuing to the Quaternary period, and probably not yet completed. The older rocks have been folded, fractured, and faulted, and on them the newer beds—especially Cretaceous and Tertiary—lie unconformably. The younger beds in their turn were folded and faulted, and a further major unconformity occurs between Paleogene and Neogene beds. Two distinct periods of severe foldings are suggested, one after the formation of the crystalline schists, and one after the Cretaceous period; and it would seem that the second continued till middle Tertiary times, constituting the chief foldings in the Balkan Peninsula. After the folding, fracture and subsidence often gave the mountain chains a direction independent of that of the lines of folding. The displacement of many of the faults was enormous, and to appreciate the magnitude of some of the dislocations (as, for example, those round the Bocche di Cattaro) it is necessary to see them. Since the second period of tectonic movements is relatively recent much of the country is physiographically 'young', and often the appearance is that of young physiography based on an old geological structure (as in parts of South Macedonia). Thus, faulted lake-basins, steep escarpments (faultscarps), and isolated plateaux indicate youth, while the central core of old rocks extends far beneath the surrounding folded sedimentary beds, and the true core area has not been covered by the sea for many epochs.

A few words may be added regarding the western mountain chains.

Cvijić (1901) describes the change in direction of these at the Drin Gulf (Medua) as an example of a 'Scharung',[1] the northern (Dinaric) and southern (Albano–Greek) mountains meeting in a tectonic centre, but being separated one from another without one arc or line cutting across the other. Later researches by Nopcsa and other geologists have led to considerable modifications of many of Cvijić's views. It seems probable that the Bosnian, Rascian, east-, north-, south-, and central-Albanian, as well as the Greek mountains (of serpentine, tuffite, and jasper-schists) form one zone reaching from Slavonia to the Gulf of Volo, this mountain zone being 'double-kneed', ⨽, near Mitrovica and Scutari. It is an open question whether the Dalmatian–Hercegovinian calcareous mountains disappear by an analogous 'double-knee' near Scutari under the Adriatic (Philippson) or again appear in the calcareous mountains near Janica and Santi Quaranta, or finally cease near Scutari.

SOILS

It is, with very few exceptions, the superficial layers of the earth's crust, especially those considered as 'drift' by geologists, which form the habitats of the plants under consideration in this work. Hence it is important to consider all the pedological facts available for the Balkan Peninsula. Unfortunately these are few, and no complete survey of this important subject can yet be attempted. I have made many observations on soil conditions in different parts of the Peninsula, but these have been either connected with water-supply or have been secondary to botanical and agricultural studies. I have had neither time to undertake full analyses nor the conveniences necessary for the work. In spite of this there are certain facts connected with the soil which can be shown to be of importance when the distribution of species and types of vegetation has to be explained.

As with all other environmental factors, the soil conditions of the Balkan Peninsula show a larger range than is to be found in any other area of smaller or equal extent in Europe, except perhaps in the British Isles. This is partly because of the many kinds of rocks which outcrop, but even more because of the very varied climatic conditions in different parts and the broken physiography. Excepting that the loess area overlaps our boundaries from the north-east, there is no great

[1] The term *Schaarung* has been used by Suess to indicate 'the relations of great folded chains to one another and the manner in which they congregate together.' Suess's great work was translated into English, under the title of *The Face of the Earth*, by H. B. C. Sollas. The above sentence is quoted from p. 422 of vol. i. (1904) of this, and there is here an editorial footnote which says, 'The English equivalent for *Schaarung* is trooping or trooping together. As a literal rendering would involve periphrasis, the word "syntaxis" has been adopted in the translation.'

regional extension of any one type of soil, such as that derived from Boulder Clay in glaciated regions.

Many classifications [1] of soils have been proposed, but none is entirely adapted to our present purpose. It is advisable to deal separately with the calcareous soils, those derived from arenaceous sedimentary rocks, those derived from igneous and metamorphic rocks, and the loess.

Calcareous rocks outcrop over an enormous area in the Balkan Peninsula, and their weathering and the resulting products vary according to local conditions. Within the true Mediterranean climatic zone they are predominant, and outside the boundaries of this the large karst districts and many parts of the Tertiary mountain chains are also of limestone. Within the Mediterranean zone, owing to the coincidence of the hot season with that of the minimum rainfall, chemical weathering is not active. Moreover, since frosts are rare, mechanical weathering is also relatively slow, except in the mountains, and it follows that the natural renewal of soil or of soil fertility is a very slow process. In addition many of the limestones have so high a proportion of calcium carbonate that on weathering they leave little residue, though what there is may be very fertile. The processes of soil destruction are, however, accentuated by the steepness of the slopes in many districts, by the heavy rainstorms of the rainy period, and by the destruction of the woody vegetation, all leading to great erosion. Therefore a great deal of barren rock is exposed, and the vegetation in many places is limited to that which does not require great soil depth. These facts are reflected in the agricultural methods. Terracing to collect soil and to prevent rain-wash, the limitation of arable land, in some parts, to valleys and lowlands where all that is available must be used for crops, the impossibility of keeping large flocks in one area throughout the year, and hence the adoption of transhumance, are all connected with the poverty of the soil covering. Thus I was much impressed by the restriction of agriculture to the lateral valleys and to the few alluvial passes in the peninsula of Sabbioncello.

It is probable that in the Mediterranean parts of the Balkan Peninsula the chemical nature of calcareous soils is quite secondary to their physical peculiarities, and that a majority of species are indifferent to the mere presence or absence of an excessive amount of calcium carbonate. So far as I know, no work on hydrogen-ion concentrations has yet been done on soils from the Balkan Peninsula, but certain facts regarding the distribution of species relative to calcareous soils indicate

[1] Reference may be made to the *Allgemeine Bodenkarte Europas*, published in *Soil Science*, xxv. 74 (1928). This is on the small scale of 1: 10,000,000, and even if it is accurate in outline it leaves much to be desired in details.

that a broad comparison with the floras of other countries on this basis might lead to important discoveries.

Limestones and karstlands. Most of the limestone areas of the Balkan Peninsula show karst features, as described below, though these are developed best in the western parts from the north of Trieste to Montenegro. I have carefully studied them on the Karst proper, in Istria, in Dalmatia, and in Montenegro. In the limestone districts of eastern Serbia and western Bulgaria (Suva Planina, Dragoman, &c.) I have botanized in areas which are becoming karst. Since limestones are so widely spread, karst phenomena have a considerable importance for our studies. I have never seen typical mature karst with a continuous covering of natural forest, but it is difficult to separate cause and effect here and to say whether the poverty of vegetation is due to the karst conditions or these owe their origin to the absence of a protective covering of plants. There is, however, little doubt that many karst phenomena are due to physical causes acting independently of vegetation, but often accentuated when this is absent or meagre. In a typical karst region, such as that north of Trieste or in western Montenegro, the following features are characteristic. There is very little surface water. In August 1925 near the village of Ležeče I saw two small ponds with water, and another not far from St. Canzian. Periodic lakes also occur in some areas, but there are few rivers and these generally disappear underground after a short course (for instance the Reka at St. Canzian). The circulation of water is almost entirely underground, and three hydrographic zones have been distinguished: (1) the zone immediately beneath the surface, composed of channels and reservoirs, which transmit water in time of storm but are usually dry; (2) an intermittently dry and wet zone, whose caverns and channels may be flooded for considerable periods but not permanently; (3) the lowest zone, situated immediately above the junction with the underlying impermeable strata, has permanent streams and reservoirs, which are always full of water. The karst limestone is naturally full of joints, and it is along these that weathering first occurs, and through the enlarged fissures thus made the water rapidly percolates. With this underground water-circulation is connected not merely the disappearance and reappearance of rivers, but also the bubbling up of freshwater springs such as occur off the coast of Crete.

The *dolines* form another characteristic feature of karstlands. These are tub-, funnel-, or basin-shaped depressions of all sizes from a few metres to a thousand in diameter, and of all depths from two to two hundred metres. Great dolines with subsidiary dolines inside them occur. Very various opinions have been held as to their origin. The views that they originate by the falling in of underground caverns,

that they are formed by the weathering action of streams in past times, by glacial action, by 'acids' excreted by the roots of plants, or by snow, have all been put forward by geologists. My own observations lead me to believe that the method of formation has not always been the same. Some dolines show clear evidence of 'falling in', as if the roof of an underground cave had collapsed, others, especially small shallow ones appear to be due to surface weathering at unequal rates, but many, probably a majority, are due to subterranean chemical weathering and more or less gradual subsidence. The first type is exemplified by the dolines of St. Canzian and some near Njegus in Montenegro, the second type I have studied between Opčina and Briščiki, and also near Sesana, to the north of Trieste, while the third type with regular outline and almost undisturbed slopes is frequent in all limestone districts in the western parts of the Balkan Peninsula. Vegetation probably hastens chemical weathering, in that by the accumulation of soil and humus it enables considerable moisture with carbon dioxide in solution to be retained in the superficial layers. It must also directly add to the carbon dioxide in solution, and this is of great importance for dissolving the calcium carbonate. In my experience a continuous covering of vegetation, such as a forest, on limestone, causes more regular weathering, or rather, the final result is that there are fewer surface irregularities, because the soil is retained and tends to fill up hollows and to round off contours. This matter will be considered more fully in describing the effect of afforestation on the karst, and in dealing with the natural karst vegetation. In addition to dolines elongated valleys termed *poljes* also occur in karst regions. The relationship of these to dolines has been much debated. They are often connected with surface or subterranean rivers, or show the previous influence of these. They are generally the most fertile parts of a karst country, because they collect and retain soil on a much larger scale than do the dolines.

The soil conditions of karst country are thus peculiar. A very large proportion of hard, bare rock is exposed. Stones of all sizes abound at the surface. Soil is formed slowly and usually fails to accumulate naturally, except at the bottom of hollows or where vegetation is fairly dense. Yet the soil which is formed is often fertile, especially when mixed with organic materials. In the beech woods of the higher slopes of Mount Maggiore in Istria, I have seen soil formation approaching that of Central Europe, but elsewhere in the karst districts the result of the limestone weathering is 'terra rossa'. The purity of the limestone is often extraordinary. Thus Bouyoucos collected about fifty samples from different parts of Greece, and these showed on analysis from 90 to 100 per cent. of calcium carbonate, most samples having 98 per cent. Very pure limestone is found in Cherso; it is nearly snow-white,

very thick, and yields very little red earth. According to Neumayr (as quoted by Leiningen) it contains only 0·044 per cent. of red coloured silicates, with a content of 20 per cent. iron oxide. Lorenz (see Leiningen) mentions Triassic limestone with 2 to 23 per cent., and Rudist limestone with 6 to 13 per cent. red coloured residue. A grey limestone from Lovrana treated with hydrochloric acid yielded 3·04 per cent. The extent to which the calcium carbonate is dissolved out naturally, is indicated by a sample of red earth which was collected between Abbazia and Lovrana and which, according to Leiningen, contained only 0·68 per cent. of CaO in the burnt dry substance. On thick beds of red earth even lime-avoiding plants may occur.

Karst and semi-karst country occupies a much greater area in the Balkan Peninsula than is suggested by a study of maps and general works of reference. It is widespread in Istria, Dalmatia, Hercegovina, and Montenegro as I have personally seen. It occurs also in Serbia, parts of Bulgaria, in Albania, the Sandjak of Novi Pazar, and Greece, and can probably be seen in a more or less intense form in every district with denuded limestone rocks. Wray (1922) gives a useful account of the karstlands of western Yugoslavia.

Sandstones. Arenaceous sedimentary rocks are less widespread than limestones, but are nevertheless important in some areas and give rise to a physiography and bear a vegetative covering often in marked contrast with the latter. This is especially noticeable when the limestones are highly karsted, as in Istria. Arenaceous soils derived immediately from igneous and metamorphic rocks and transported at most only short distances will be considered later, as will also the loess. Here we are chiefly concerned with soils derived from the sandy and gravelly beds in the 'flysch', largely of Upper Eocene Age. Such beds are often loose and weather rapidly, to give deep, easily worked soils. The vegetative covering, whether natural or cultivated, is usually more continuous than on limestone, and the retention of water is thus aided and, in its turn, favours the vegetation, in spite of the naturally porous nature of the deposits. Soil formed immediately from some of the arenaceous beds is markedly poor in organic material and in some soluble food substances, but vegetable humus accumulates in it rapidly, as I have observed near Capodistria.

Soils derived from igneous and metamorphic rocks. We have now to consider the soils yielded by the igneous and metamorphic rocks, especially those of the central core of the Balkan Peninsula. Both acid and basic rocks outcrop, but the former and intermediate kinds are predominant. These rocks chemically weather more slowly than limestones, and since they contain a much larger proportion of less soluble minerals they yield a more abundant residue and a deeper soil.

Moreover, since they often occur in mountainous districts outside the typical Mediterranean climatic zone, mechanical weathering plays a more prominent part in their disintegration than it does in that of the Balkan Peninsular limestones, which are largely coastal. It is true that much of the soil does not naturally remain in situ on the slopes, but, with few exceptions, I have not seen hills and mountains of igneous or metamorphic rocks anywhere in the Peninsula so rocky and with such lack of a continuous covering of vegetation as the limestone hills and plateaux of the Karst proper, of Istria, South Dalmatia, Hercegovina, Greece, or Dragoman in Bulgaria.

The igneous rocks are of many kinds, and the local geological history has been so varied that it would be difficult to give a brief summary of the soils produced from them, even if our knowledge were much more complete than it is. Often the soils originating from igneous and metamorphic rocks have been moved by water, either as rain-wash or by streams no longer in existence. When this happens there may be a sorting out of materials. Thus, just west of Karamudli, on the southern lower slopes of the Krusa Balkan, South Macedonia, I have dug down ten feet into almost loose pure sand, which has been derived by water action from the disintegration products of mica-schists containing a high proportion of quartz. Again we have to recall that many of the valleys are filled with the more or less decomposed debris of the hills and mountains deposited in arms of the Sarmatic Sea, or in Pontic or Levantine lakes, or washed down by the greater rainfall of the Pluvial period. The compactness and degree of decomposition of such lacustrine, alluvial, or diluvial materials vary greatly. West of Salonika there are hard, compact deposits formed of a mixture of broken pieces of igneous and metamorphic rocks in all stages of decomposition; while in other parts of the same area masses of similar material are loose, and in these it is relatively easy to dig trenches! Frequently such mixed transported materials yield exceedingly rich soils. Thus in a valley east of Karamudli, around the village of Jeni mah (Turkish in population in 1917), I have seen in the middle of July natives sowing maize immediately after a wheat crop had been reaped—before even the sheaves had been carried. Two cereal crops in one season, without the application of any fertilizers, could only pay on an extremely rich soil, yet the crops in this valley were finer than any I have seen elsewhere in Greek Macedonia.

Serpentine rocks are very widely distributed in the western and southern parts of the Balkan Peninsula. Their weathering leads to soils rich in magnesium. H. C. Boydell has an interesting paragraph in a paper on the magnesite deposits of Euboea.[1] He says:

[1] *Economic Geology*, December, 1921, 507.

'The central serpentine area is the best watered and most fertile portion of Euboea, the contrast which it offers in this respect with the typical Karst appearance of the surrounding limestone being most striking. This is particularly noticeable on the journey by steamer from Chalkis to Limni, the green environs of the latter looking like an oasis in a desert of limestone. Its hills, where they have not been stripped, are covered with a growth of pines. . . .'

In the western mountains, where the rainfall is greater, the serpentines readily disintegrate, but form a soil poor in many of the salts necessary to plants. Thus the communities characteristic of serpentine substrata are often relatively poor in species. A number of species appear to be limited to serpentine soils in the Balkan Peninsula, and so-called forms and varieties of species usually occurring on other soils have been described from serpentine districts. Thus Pančić [1] gives a list of forty species and varieties which he had observed on the serpentine soils but not elsewhere in Serbia.

Loess. The loess has the most continuous distribution of any one type of soil within the Balkan Peninsula. It covers much of the Dobruja and a zone of the Danube plain in North Bulgaria, about 20 to 30 km. broad from the Timok valley to the Black Sea. It is mostly of aeolian origin, and like many other transported soils is in itself generally very fertile. However, lack of sufficient water at all seasons is a limiting factor to this fertility in some parts, especially in the Dobruja. The mixture of dust and sand was probably caught by low vegetation, especially grasses, whose roots on dying became incrusted with calcareous material, and thus led to increased porosity, with the result that water quickly percolates through the loess covering to come to the surface again at a lower level, in our area most often at or close to the Danube. Chemically, loess forms one of the richest soils in the world, containing plenty of available calcium, potash, and phosphorus, and it is also one of the easiest to work owing to the absence of stones. In the Dobruja the loess has a great thickness (up to 60 or 80 m.). The loess, in areas with considerable temperature extremes and irregular water supply, is usually covered with some type of steppe. It is interesting to note that in some parts of the Dobruja forest is invading the steppe. The absence of loess in the Mediterranean region has led to the suggestion that in the Quaternary epoch this area was forest-covered.

Coastal soils. Coast terrains of markedly different types from those of inland districts are less prominent than in many other regions. This is partly due to the very weak tides of the Mediterranean and its associated seas. Very often terrestrial vegetation extends to within a foot or two of the sea, as I have seen in Istria, Dalmatia, South Macedonia, Thrace, Bulgaria, and elsewhere. Cliffs and steep rocky shore-lines are

[1] *Verhl. Zool.-Bot. Ges. Wien*, ix. 139 (1859).

not infrequent. Sand-dunes and salt-marshes are relatively rare, though they occur in Greece and the Gallipoli Peninsula, while sandy shores with halophytes occur on the Black Sea in eastern Bulgaria and the Dobruja.

In concluding this general account of the soils it may be noted that the agricultural methods employed throughout the Balkan Peninsula rarely include the use of fertilizers or the regular application of manures. Animal excreta are often valuable as fuel, and the practice of transhumance and the feeding of flocks and herds on the open hillsides prevent the accumulation of farmyard manure. Land is frequently left fallow where sufficient is available for use, and the abundance of *Leguminosae* must aid in the renewal of soluble nitrogenous salts. For the wild vegetation the poverty of the soil under natural conditions is rarely a limiting factor. Earthworms appear to be rare in parts of the Balkan Peninsula, especially in South Macedonia.

REGIONAL GEOLOGY

We have now to survey briefly the chief geological features of each of the areas into which we have divided the Balkan Peninsula and its surrounding islands.

1. **Crete.** Geologically Crete is part of the Alpine–Dinaric–southern Asia Minor fold system, however these folds have been brought about. This system has been broken across and locally fallen in, so that chains of islands have been formed. In Crete the structure is complex, for in the west the folds run from north to south, curving gradually towards the south and west coasts. In the east the folds appear to run from west to east and to be the continuation of the Dinaric–Albanian–Greek folds of the Balkan Peninsula proper. The structure is further complicated by a great thrust plane which has brought the Jurassic and Lower Cretaceous beds upon the Upper Cretaceous and Eocene beds. There are great series of metamorphic rocks in western Crete, of very varied composition. The later beds of the island belong to the Jurassic, Cretaceous, and Tertiary systems. Lower Cretaceous limestones, schists, and cherts, Upper Cretaceous limestones with *Rudistes*, and Eocene beds with nummulites occur, and are all involved in the earth movements to which the mountains of the island owe their formation, but the Miocene beds (with *Clypeaster*) and later deposits lie almost undisturbed upon the coasts and low-lying ground.

It is probable that prior to the first formation of the Aegean Sea Crete was in land connexion with Asia Minor, and even now the distances, via Karpathos and Rhodes, to the mainland are not great. The possible previous connexion of the island with North Africa is of great interest to us. As in the Maltese islands, so in Crete, a number of

Pleistocene fossil mammalia, some apparently of African type, are found in caves and superficial deposits. The remains of at least eight species of mammalia have been obtained. These include those of a large elephant (*Elephas antiquus*); a pigmy elephant (*E. creticus*), hardly more than three feet in height; a dwarf hippopotamus (probably *Hippopotamus pentlandi*) not very much larger; a deer (*Anoglochis cretensis*) about the size of a roe-deer; a goat (probably *Capra aegagrus*); a shrew (*Crocidura*); a spiny mouse (*Acomys*); and a rat (*Epimys rattus*). The extinction of the deer is, geologically speaking, of quite recent date, since its horns have been discovered in the shrine of the Snake Goddess in the Palace of Knossos. While it is obvious from their affinities and the distribution of their fossil remains and those of allied types, that these animals must have wandered over a larger land-mass, and that they themselves or their ancestors must have originally come from a continental area, I have found nothing to suggest that Africa rather than South Europe or Asia Minor was the mainland. Thus fossil elephant and hippopotamus remains are common in south European strata of late Tertiary and Pleistocene Ages.

The geological relationship of Crete and Cyrenaica is important. J. W. Gregory [1] has suggested that both Crete and Cyrenaica are of the nature of 'horsts', being bounded (seawards) by series of faults. He says 'the faults no doubt belong to the same series as those which in recent geological times (from Upper Miocene to Pleistocene) broke up the land which extended from Cyrenaica to the Balkans, formed the Aegean Sea and its Archipelago, and fractured Greece'. If this is a true conception we should expect to find that the floras of Cyrenaica and Crete showed a close relationship. It should be noted that this possible Pleistocene connexion of the Balkan Peninsula and part of present North Africa has nothing to do with the African affinities of the Middle Tertiary Pikermi and associated faunas.

2, 2a, 3, 4. **Greece, Cyclades, Thessaly, and Epirus.** It is convenient to consider these together. Structurally there are two main folded regions, the western and the eastern. The former comprises all the mountains eastwards to, and including, the Pindus, Olonos, and Messenian ranges, with the direction north-north-west to south-south-east. Within this region Archaean and Palaeozoic deposits do not occur at the surface. Mesozoic beds from the Upper Trias upwards are present, and occur in two facies: the one consisting of massive limestones which pass upwards to the great deposits of Eocene nummulitic limestones and Eocene and Oligocene flysch, the other mainly of schists and laminated Olonos-limestones. An enormous over-thrust has brought the Olonos-limestone on to the top of the other massive

[1] *Geogr. Journ.* xlvii. 321 (1916).

limestones and flysch in many areas. All the beds have been intensely folded, probably in Oligocene times. In the eastern region there are two extensive masses of crystalline (Archaean) and probably metamorphic rocks on the surface—the Thessalian and Cycladean masses, the latter also including eastern Attica and southern Euboea. Between these two masses are sedimentary folded mountains with a general east and west orientation, at right angles to that of the western system. This eastern zone of sedimentary mountains includes southern Thessaly, eastern central Greece, and the greater part of Euboea and Argolis. The rocks are of Palaeozoic and Mesozoic Ages. The nummulitic limestones and flysch of the Paleogene are lacking, and the folding probably began in Eocene times. Between these two main regions there is interpolated in the central Peloponnese a third, which is related to the western region but has crystalline (metamorphic) schists. The crystalline mass of Thessaly is to be considered as a part of the great Rodope massif. The western region is linked on to South Caria and West Lycia by the Crete–Karpathos–Rhodes island bow and the Cretan Sea, while the rest of western Asia Minor, with its great central crystalline mass and surrounding folds, is analogous to the eastern region of Greece, though the full connexion has yet to be traced. The Oligocene was the chief period of folding according to the latest evidence.

We have already traced (pp. 21–3) the transgressions and regressions of the marine Miocene (Mediterranean stages) around the edges of, and into the valleys and lowlands of the folded region. The deposition of the vast lacustrine (Levantine) deposits of the Aegean and other areas, and the final formation of the Aegean Sea and Archipelago by the breaking up of the Greek–Aegean–Asia Minor continent, have also been considered.

The mighty tectonic forces which brought about the last great changes are not yet all spent, for earthquakes are exceedingly frequent in Greece, the Cyclades, and the Aegean area generally, and Santorin is still active, having erupted and produced a new islet in its crater as recently as 1925 (see *The Times*, August 14, 1925). The geologically recent connexion of the southern part of the Balkan Peninsula with Asia Minor is fully established and is a fact of supreme importance in phytogeographical studies.

4a. **Corfu.** The island is mainly formed (superficially) of Pliocene beds. Some Jurassic, Cretaceous, and 'Flysch', and a little Miocene also outcrop.

5. **Albania.** The geological structure of Albania as a whole is not well known. Recent research indicates that the Albanian mountain systems are essentially a part of the Dinaric and Greek series of ranges,

and the earlier views of Cvijić regarding the break in continuity inland from the Drin Gulf have been considerably modified. The outcropping rocks are predominantly of Cretaceous age. The Trias appears around Lake Scutari, and in the complicated district of the Lower Drin Permo-Carboniferous and Eocene rocks also appear. Ophiolitic rocks and diabase occur in patches and narrow belts, crossing and extending south of the Lower Drin, below the confluence of the White and Black Drin. Such rocks also appear south of Koritza, in the Grammos and adjoining ranges. In the west, Eocene rocks appear between Antivari and Dulcigno. Here also is found the 'flysch' formation, composed mainly of sandstones, soft marls, and sandy shales, which are again seen north-west of Elbasan, and much more extensively farther south. A belt of flysch runs south-south-east from near Berat to the Upper Vojusa valley, and there is a wider belt of it east of this in the Grammos ranges and farther south. To the west, towards the coast, there are other belts of flysch. Miocene rocks border the Cretaceous, and appear between them and the Pliocene, Quaternary, and alluvial deposits of the maritime plains of the Shkumbi, Semeni, and Vojusa. These most recent deposits are characteristic of the coastal lowlands farther north, inland round the east and north shores of Lake Scutari, and in the upper basin of the White Drin to the east of Ipek, Jakova, and Prizren, where also the bordering Miocene rocks again appear.

6. **North Macedonia.** This area consists, in the main, of crystalline metamorphic and hard Palaeozoic rocks, forming high mountainous country. On the plateau there are several marked depressions, including the tectonic basins of Monastir (Bitolj), Tetovo, Skoplje (Üsküb), Metohija, and Lakes Okhrida and Prespa. The solfataras and great masses of the late Tertiary volcanic rocks bear witness to comparatively recent earth movements affecting these areas. The majority of these basins were filled by arms of the Sarmatian Sea or by lakes or lake-arms of Pontic age. They are, therefore, frequently floored with a productive soil produced by the brackish or lacustrine deposits. In the extreme west on the Albanian borders the tectonics are complex, and Palaeozoic and Mesozoic rocks and serpentine outcrop.

6a. **South Macedonia.** Primarily the area consists of hard crystalline metamorphic rocks arranged largely in folds running north-west to south-east and also showing traces of cross folding. Much of the lowland was covered later by Sarmatic and Pontic deposits. Finally, great crustal movements resulted in numerous and enormous dislocations, so that large blocks of crystalline rock, bounded by great faults, rose or sank. The most violent, as well as probably one of the latest, of these series of movements was that which broke up the southern area, which foundered and gave place to the Aegean Sea, whose formation

led to the draining of the low basins, though the many large lakes indicate that this process is not yet completed.

6b. **Athos Peninsula.** The peak of Athos is of marble, but the peninsula is composed mainly of mica-schists with some conglomerate and limestone.

7. **Thrace.** A considerable part of Thrace belongs to the old crystalline land mass previously mentioned, and is geologically the northern rim of the Aegean continent and an eastern continuation of the eastern part of South Macedonia. Cretaceous, Tertiary, and Quaternary deposits cover the lowlands and surround the margins of this mass. The Lower Maritsa and Ergene basin is mapped as covered with Quaternary deposits. To the south and east of this Sarmatic–Pontic beds predominate. In the north of the Gallipoli Peninsula there are sandstones and marly slates of the Upper Cretaceous period; above these, but farther to the south, there follow 6,000 m. of Tertiary sediments, which in the Straits are crowned by Sarmatic deposits (marls, sandstones, and conglomerates) and Pontic limestones, together 150 m. in thickness. These Sarmatic–Pontic beds are nearly or quite horizontal, whilst the older rocks are folded, and on the north coast of the Peninsula form a hilly landscape up to 400 m. in altitude. The strike of the folding is nearly coincident with the long axis of the Peninsula. A young Pliocene (Levantine) elevation of the land gave origin to the erosion furrows and fluviatile rubble. A still younger disturbance (light folding and faulting) accompanied the invasion of the sea into its present basin and moulded the existing relief in its general features. The area around Constantinople and the Bosporus is chiefly built up of Devonian rocks. The Aegean Sea is of geologically very recent formation, and the separation of Europe and Asia at the Dardanelles and Bosporus must have succeeded its origin. Probably they are both, partly at least, old river valleys.

7a. **Thracian islands.** These are basically parts of the older Aegean continent and are largely composed of crystalline rocks, partly overlain by Sarmatic–Pontic deposits.

8, 8a, 8b. **Bulgaria.** The Stara Planina (Balkan Mountains) continues the Alpine–Carpathian folds to the east, and lies between the Rodope mass to the south and the predominantly Cretaceous foreland to the north. Towards the Danube it descends somewhat gently, but on the south, where there has been much faulting, the slope is more abrupt and is frequently marked by volcanic outpourings and thermal springs. In the west the Stara Planina is composed mainly of crystalline schists alternating with broad belts of limestone. To the east of the Isker gorge an extensive area of Carboniferous formations, pierced in places by granitic rocks, extends eastwards, with a gradually

decreasing width, as far as the headwaters of the Vid. Farther east crystalline schists reappear, not only in the main range but in the detached masses of the Sredna Gora and Karaja Dagh, with considerable areas of granite. North of the older rocks, and separating them from the Cretaceous formations, are broad belts of flysch. East of Slivno the region consists of gently folded Cretaceous rocks, chiefly limestone. To the north of the Stara Planina the folded limestones gradually pass into the horizontal strata of the Balkan tableland. Here again the prevailing rocks are Cretaceous limestone and marls. In the Deli Orman the weathered, dissected limestone presents many of the karst characteristics. The northern parts of Bulgaria are covered with loess, and the river-valleys with alluvium. The basins of Sofia, Philippopolis, and Stara Zagora are covered with Quaternary deposits, though on their margins Tertiary rocks outcrop. The Rodope mass is largely composed of Archaean gneiss, marble, and granitic rocks. The Vitoša, with its highest peak Črni Vrh (2,286 m.), is largely composed of a mass of syenite. Penck (1925) has suggested that this was formerly covered by a red sandstone and that the mountain mass has had a history largely independent of the surrounding mountains, being essentially older than they, but that during the Pliocene epoch it became inconsiderable and was later again raised in height. If this is the true history of the massif it explains the absence of various high mountain species common to the Rila, Rodope, and Stara Planina, yet absent from the Vitoša. Some of the Bulgarian geologists, however, do not accept Penck's views. Pirin is composed of granitic rocks, crystalline schists, and crystalline limestones.

9. **Dobruja.** The Mesozoic and Tertiary deposits are almost entirely covered by loess, and only appear in the gorges and in a few localities. In the north, however, a mountain mass of old rocks, over 450 m. in altitude, projects above the loess covering. Lying between the Danube and the Black Sea this range has no geological connexion with the Carpathian mountains or Stara Planina, but is more likely to represent the remnants of an old mountain-land reaching to the Crimea, and perhaps the Caucasus.

10. **Serbia,** and 10a. **Novi Pazar.** These areas consist of two main divisions: (*a*) in the east is the terminal portion of the roughly triangular mass of Archaean and metamorphic rocks, which has its base on the Aegean Sea and reaches to the north of Serbia, (*b*) in the west is part of the folded belt which extends along the whole of the western part of the Balkan Peninsula and reaches into Serbia. The movements of the mass and the belt have mutually affected each other, and parts of the country are tectonically transitional between the folded rocks to the west and the older faulted mass. Gneisses and schists are

characteristic of the latter. The predominant schists are bounded and overlain north of a line between Novi Pazar and Nish by a complex of various formations, among which not only Cretaceous but also Carboniferous rocks are prominent.

11. **Montenegro.** Excepting the lowland plains, the area is essentially one of mountainous karst limestone structure. Quaternary beds are limited to isolated areas, chiefly in the river-valleys and near Lake Scutari. The Tertiary rocks (marine Neogene beds, coastal flysch, and nummulitic limestones) all occur in coastal exposures, for the most part as narrow bands running north-west to south-east. Cretaceous rocks form a broad band in the centre of the country, running from near Cetinje to near Lukovo, and from the south-east to the north-west boundaries. Jurassic rocks occur as outliers in the Triassic beds, which form two bands with the same north-west to south-east direction of outcrop. The broader Triassic outcrop occupies the greater part of the north-western and north-central portions of the country except where covered by Cretaceous and Jurassic outliers. In the north-east it is denuded and older Palaeozoic rocks are exposed, old erupted rocks being also found. The narrower band outcrops to the south-west of the main Cretaceous exposure and stretches from the coast, except where it is overlain by younger deposits, to near Cetinje and the Scutari lake.

12. **Bosnia**, and 13. **Hercegovina.** The highlands of these areas form a continuation of the south Alpine calcareous belt. Along the western boundary appear broad and well-marked zones of Cretaceous, Jurassic, and Triassic beds, especially of limestone, joined by a strip of Palaeozoic formations running from the north-west corner of Bosnia. To the east are Neogene freshwater and brackish-water deposits, filling up the greater part of north-eastern Bosnia, as also a zone of flysch intermingled with eruptive rocks. In the south-east of Bosnia, Triassic and Palaeozoic strata predominate, with red sandstone and quartzite. In the valleys and along the northern rim of Bosnia diluvial and alluvial deposits form the surface.

14. **Dalmatia.** Tectonically the whole of this area, composed mainly of Tertiary, Cretaceous, and Triassic rocks, is a continuation of the Julian and Istrian folded mountains, and many parts exhibit the characteristics of broken denuded karst limestone. Except for a few marshy estuaries, the entire rocky coast is almost devoid of alluvial or beach formations. A large percentage of the heavy annual rainfall runs to waste through subterranean channels. Two main folding and dislocation periods of the Dinaric karst have been suggested: the one in the older Miocene, and the other at the end of the Pliocene. The Dalmatian coast is in many places bounded by steep fault-surfaces, and shows every sign of great tectonic activities.

15. **South Croatia.** This is essentially a continuation northwards of Dalmatia and is a great contrast to much of northern Croatia. As in Dalmatia, Triassic, Cretaceous, and Tertiary strata predominate, especially the two former, and much of the country is strongly karsted.

16. **Istria.** The predominating rocks are of Cretaceous and Tertiary age. The former are almost entirely calcareous, consisting of radiolitic limestones and 'rudist' limestones, the latter, forming the main body of the karst, are interrupted here and there by white breccias or by dolomitic rocks. Dark bituminous limestone also occurs. The Lower Eocene is represented by nummulitic limestone and forms the slopes which surround the amphitheatre of Trieste, besides occupying much higher ground. The Upper Eocene is exclusively arenaceous (flysch) and alternates over large areas with the karsted limestones.

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III

CLIMATE

THE PENINSULA AS A WHOLE

General. Since the Balkan Peninsula, as understood here, has a north to south extension from 45° 46′ N. to 34° 45′ N., and an east to west extension from 29° 20′ E. (Greenwich) to 13° 30′ E., it would naturally be expected to show a considerable range of climatic conditions. But the configuration of the coast, as expressed by the distance of any given area from the sea, and the arrangement of the mountains and plains have a greater modifying influence on the climate of a district than mere latitude and longitude. This fact is strongly reflected in the vegetation, as will be shown later.

Essentially the Balkan Peninsula is an irregularly triangular, mountainous land-mass, projecting from its base in Central Europe into the Mediterranean basin. It differs markedly from the Iberian and Italian peninsulas in that it is not cut off from the mass of the continent by a continuous east and west range of mountains comparable with the Pyrenees or the Alps. For these reasons we find two main climatic domains represented, the Mediterranean and the Central European, but they merge into each other in many districts, and often the distribution and the extremes of temperature, precipitation, and pressure are very different for places only a short distance apart. Moreover, the Mediterranean climate as represented in the Balkan Peninsula is that of Martonne's second Mediterranean type, Continental or Hellenic, showing greater extremes than the Oceanic or Portuguese type.

The whole of the Balkan Peninsula lies within the North Temperate Zone and in the (theoretical) region of winter south-west anti-trade winds, and the southern part in that of the summer north-east trade winds. The weather conditions of Western Europe are, however, largely controlled by the high pressure system of the Azores and the low pressure system of Iceland. The Balkan Peninsula is overlapped by the Atlantic area of high pressure centred at the Azores, and at the same time its northern and central parts are influenced by the pressure system of continental Asia. The distribution of atmospheric pressure which determines the air-circulation over the Balkan region during winter differs essentially from that which prevails in the summer months. In January the vast high-pressure system of Central Asia is extended into the Balkan Peninsula, while a less strongly marked ridge of high pressure lies over North Africa. The Mediterranean basin is an

area of low pressure, along which numerous cyclonic depressions pass throughout the winter. Thus northerly winds predominate, but the frequent passage of depressions along the Mediterranean (when a slight lowering of pressure over Central and Eastern Europe brings the low pressure zone a little farther north than usual, across the Balkan Peninsula), gives rise to a large proportion of southerly winds at all stations. These winter cyclones bring the rain, but the air which travels southwards on the back of the depressions is the cold winter air of Eastern Europe, and, since the pressure gradient is often steep and the air descends from high plateaux down funnel-like valleys, the north wind in the rear of winter cyclones is frequently of great force. The cyclones often move slowly, and the gale may last for two or three days in any one place. The pressure over the Balkan Peninsula and South Russia falls gradually during the early part of the year, and by June the Persian Gulf and North-west India constitute a strongly marked low-pressure area which is related to the monsoon of the Indian Ocean. This distribution of pressure reaches a maximum in July and August, and the mean isobars for these months run nearly parallel north and south across the eastern Mediterranean basin till, between the latitudes of Athens and Salonika, they bend almost at right angles across the Aegean Sea and Asia Minor. Thus there is brought about a general flow of air from the north-west over the eastern Mediterranean, and only in October, when the low pressure in the Persian Gulf has passed away, does the change from summer to winter conditions take place. Within the areas of Mediterranean climate the summer corresponds with the desert conditions south of the Mediterranean basin, that is, it is dominated by the dry trade-winds. The winter, on the contrary, corresponds with the Central European climate of anti-trade winds from the ocean. Thus the Mediterranean climate is itself transitional between the climate of the desert Sahara (with no regular rain) and that of Central Europe (with a nearly equal seasonal distribution of rainfall). The northern winds of summer blow from a colder to a warmer region and take up, instead of precipitating, moisture. Cyclonic formations are rare and, apart from the influence of mountains, the summer is dry.

The tables of mean relative humidity for the day are given on the usual percentage basis. I have not been able to obtain them for so many localities as is desirable, but a number of interesting facts can be deduced from those given. The highest figure is 85 for Kavalla in February and December. The lowest is 46·3 for Athens in August. Compared with the oceanic climate of the British Isles the relative humidity is on the whole very much lower. Of the localities for which figures are given Kavalla has for each month the highest relative

humidity. The greatest range for one locality is shown by Athens with December 74·5 per cent. and August 46·3 per cent.

Climatic Divisions. The geographical position and the mass of land of the Balkan Peninsula enable us to suggest, in conjunction with the above generalizations, the following main climatic divisions:

1. *The Hellenic.* This includes the whole of Crete, the Peloponnese, the Cyclades, a broad eastern coastal belt up to the north of Thessaly, and a coastal belt on the west up to Corfu. The division is characterized by very hot, dry, sunny summers, and winters without frost on the coasts. The average rainfall for the three summer months is less than 50 mm. There is a well-marked rainfall maximum in November, December, and January.

2. *The Eastern Adriatic.* This is a relatively narrow coastal strip, up to the centre of the Istrian Peninsula (excluding the Croatian coast). It has an essentially Mediterranean climate but the summer rainfall averages between 50 and 100 mm., and maxima occur in spring and autumn.

3. *The North Aegean.* This includes South Macedonia, western Thrace, and part of eastern Thrace. It is again essentially Mediterranean in character, but is transitional to the Central European type in that it has colder winters and relatively greater summer rainfall than 1.

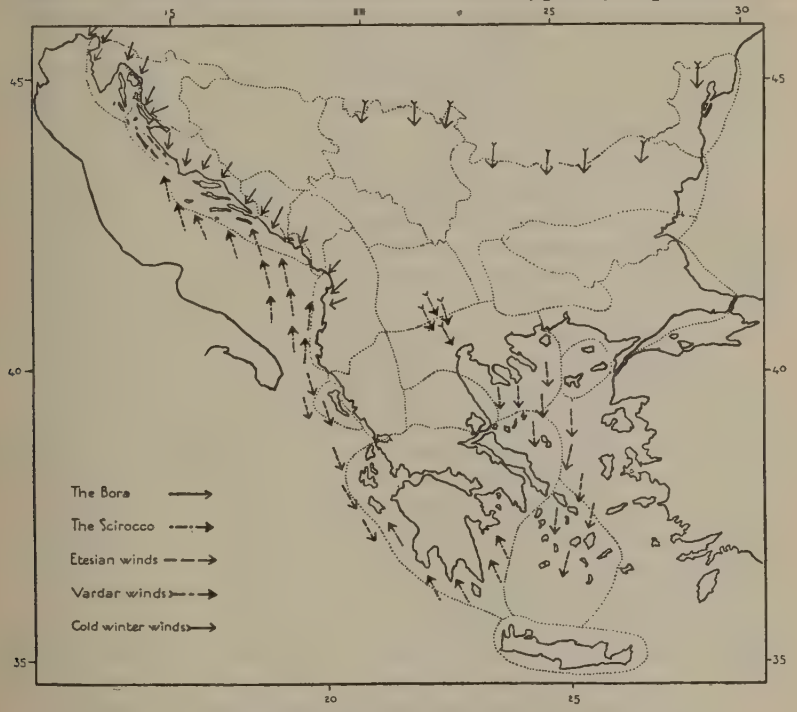
4. *The South Pontic.* This includes most of eastern Thrace and South Bulgaria, and is transitional between the Mediterranean, Central European (Danubian), and Caucasian types. Rain is distributed throughout the year, but most falls in winter. The winter cold is greater than in any of the other divisions.

5. *The Danubian.* The rest of the Balkan Peninsula, that is the whole of the central and northern parts, with a southern prolongation in the Pindus, is essentially Central European in character, with rain in all seasons, and winters cold for the latitude.

Winds. Within these main divisions there are numerous local variations which will presently be considered. But we must first deal with an aspect of the climate which deserves detailed treatment, namely the winds. In the Balkan Peninsula, and especially in those parts which come within the Mediterranean region (in the botanical sense), the lower atmosphere is rarely still, strong winds or breezes being the rule. The winds, indeed, by their constant recurrence, and by their dreaded consequences, have attracted the notice of the inhabitants from the dawn of civilization. Thus we find the ancient Greeks used many names for the regular winds, and some of these have continued in use for the same winds to the present day. Other new or modified names are also in use. Naturally the empirical classification

of mariners and others is not exact, and the nomenclature is frequently duplicated and not always easy to follow, but the account given below is as complete as I have been able to make it.

The *bora* (the Italian name which is most used) is the *boreas* of the ancients and the *vorias* of the modern Greeks. This is essentially a gusty, strong, land wind. It occurs especially in winter, though it is by no means limited to that season, and is most typically experienced in



The Principal Winds of the Balkan Peninsula

the northern parts of the Adriatic basin, at right angles to the coast, that is from the north-east and east-north-east. The true bora is an anticyclonic 'Fallwind', which occurs on the steep coasts, separating a warm sea from a cold inland area. It appears if the air pressure mounts quickly over the hinterland of the coast while remaining low over the warm sea, and in winter on the eastern Adriatic the thermal and pressure gradients are often amongst the steepest in Europe. The wind rushes from the plateaux and mountains down the steep slopes as a cold deluge. The bora is normally cold and dry, but may cause rain if it competes with the scirocco. The velocity at Trieste has been

measured by Mazelle, not in the strongest bora, as 50–60 m. per second. Its gusts are called 'refoli' in the Adriatic region. Its effects do not pass far out to sea, and in the shelter of mountain peaks and ranges of a certain orientation they may not be felt. The detailed distribution of the bora is of great importance to the vegetation, since it is a limiting factor for the macchie and other associations on the north-east coasts of the Adriatic Sea—notably in the Quarnero. On the Adriatic the bora rarely lowers the temperature to freezing point and there is frequently a meeting of the stormy warm scirocco and the dry cold bora. The *graegos* (*kaikios*) of Greece, the *tramontana*, and the *levante* (the *apeliotes* of the ancients) are also land winds, scarcely distinguishable from the bora. The first blows from the north-east or east, the second always from the north, and the third from the east-north-east or east. The mild forms of summer bora, when thermal and pressure differences between land and sea are not so great, are sometimes referred to as the *borino* or *borinetto*.

The *etesian* winds of the Greeks, the *meltemi* of the Turks, are persistent, strong, northerly winds which blow over the eastern Mediterranean during the summer months. They are divisible into two classes, the preliminary *prodroms*, which blow in the early summer about the second half of May and are neither very regular nor very stormy, and the true *etesians* which, after a break, usually occurring in June, when the winds are variable, become fully established in July, and gradually die out towards the end of September. The etesians blow over a wide area, but are more persistent and reliable over the Aegean Sea than over Greece; and whereas in the Ionian Sea the direction is rather west of north, in the Aegean area it is east of north. As a rule the strength of the wind, which not infrequently reaches fifty miles an hour by day, drops light at night in consequence of a diminution in the steepness of the controlling barometric gradient as the land surface cools down. The etesians are fundamentally caused by the summer low pressure near the Persian Gulf, and are thus dependent on the same cyclonic centre as that which regulates the south-west monsoon. Their comparatively low humidity, high temperature, and high speed occasion considerable evaporation, so that they exert a fairly refreshing physiological influence on man except for their stormy force and the clouds of dust they raise. There is thus an association of the fine sunny weather of the summer Mediterranean with winds of storm force.

The *Vardar winds* of South Macedonia are northern or north-westerly land winds of a strong dry type, frequently rising within an hour and lasting two or three days. They usually end as abruptly as they begin. The wind descending from the high inland areas into the trough of the Vardar frequently accompanies a sudden rise of the

barometer. These winds are usually characterized by hard, clear skies and exceptional visibility. In winter, coming from the snow-clad mountains of the interior they are cold winds of continuous gale force, and even in summer they are usually cool, affording a relief from the hot, calm weather.

The name *scirocco* is given to essentially south winds varying in character in different parts of the Balkan Peninsula. In Greece it is the *euros* of the ancients and is a hot, exceptionally dry sea-wind, often from the south-east. The name *notia* or *'ostria* (*notos* of the ancients) is given to a damp, warm, rain-bringing south wind. The *livas* or *garbis* of Greece (*lips* of the ancients), the *libeccio* or *garbin* of the Adriatic, is the moderately warm, oppressive, rain-bringing south-west wind. In the Adriatic parts of the Balkan Peninsula the scirocco is a damp, warm, enervating wind from the south or south-east. It usually brings rain, but in summer may blow for a day or two without any rain falling, in which case the air is extremely oppressive. This wind is particularly strong and rain-bearing at the equinoxes, and may then blow uninterruptedly for one or two weeks. It is, together with the steep mountain barrier, the chief cause of the high rainfall of the western coasts of the Balkan Peninsula.

The *ponentis* of the modern Greeks (the *zephyros* of the ancients), is the mild, gentle west wind, bringing clear weather. Finally the *maestros* of the Greeks (the *argestes* or *skiron* of the ancients) is the cold, clear, fresh north-west wind, commonest at mid-day and dying completely at sunset.

The northern and central parts of the Balkan Peninsula, coming as they do definitely within the Central European climatic region have fewer regular winds than those parts within the Mediterranean climatic region, and the proportion of calm days is very considerable, while gales are very infrequent except in the uplands. When a broad belt of equal and moderately high pressure extends over the Balkan Peninsula light southerly or northerly and north-westerly winds prevail according to the position of contiguous low-pressure areas. Cyclonic disturbances are frequent in the winter, less frequent in the summer.

DISTRICT CLIMATES

The important climatic characteristics of each of our districts of the Balkan Peninsula have now to be considered.

1. **Crete.** The island is entirely within the zone of Mediterranean climate and is the southernmost of the districts here adopted. In Canea quite 50 per cent. of the year's rain falls in November and December, when the precipitation is mostly of 'cloud-break' character.

The last rains are at the beginning of April, after which the persistent summer drought lasts till October. During seven months only about 7 cm. of rain falls, that is, only about 11 per cent. of the yearly fall. Canea has a mean July temperature of 25·7° C., yet oppressively hot days are the exception. The nights are cool even in summer. The January mean at Canea is 10·8° C., while the mean minimum on the coast is not below 5° C. The high mountains are covered with snow in November, and in February it also reaches the high-lying villages. It occurs more rarely on the coast and then only lasts a day or two. The scirocco is, in Crete, a hot wind blowing from North Africa. The air is filled with sand and the temperature mounts to 35°–40° C. It blows especially in June and for south Crete this is the hottest month, while on the north coast the highest monthly means are reached in July and August. A bora-like, gusty, fall-wind is characteristic for the winter and early spring months, when the air in the mountains is cold but that over the lowlands is already somewhat heated. The activity of much of the vegetation is never completely broken.

2. **Greece.** The climate of peninsular Greece is Mediterranean, of the Continental type; that is, the total annual precipitation is relatively small and the differences in average temperatures of winter and summer are notable. Thus Athens has a mean January temperature of 9·3° C., only slightly above that of Marseilles 3° to the north, and a mean July temperature of 27° C. The mean minimum reaches – 1·6° C. The mean yearly sum of rainfalls is 343 mm. at the same place. Thus the mean temperature extremes are greater than those of Canea and very much greater than those of the Oceanic type of Mediterranean climate (for example, Lisbon), and the rainfall much less (Canea 617 mm., Lisbon 731 mm.).

Spring, which begins in February, is of short duration and is marked by frequent changes of temperature. The summer heat increases rapidly in May and reaches its maximum in July and August. In the high mountainous districts the summer heat only prevails later and is not so intense as in the lowlands. Cloud formation is possible here, the rainfall of the summer months is increased, and the climate shows more resemblance to that of Central Europe, a fact which finds expression in the vegetation. In the summer the northern etesian winds almost entirely prevail, and coming from a cooler region lose in relative moisture with the heating and thus bring no rain. The summer is, therefore, almost rainless, and the streams are reduced to mere trickles of water or dry up entirely. Autumn begins in the latter half of September. In November winter conditions prevail, but the period of greatest cold does not arrive until January, and even then is not very great in the lowlands. The winter is the period of heaviest rainfall, but

the wet weather rarely lasts for long at a time, being frequently interrupted by spring-like days. Indeed, on an average, in winter rain falls only on 10 or 12 days in a month. The coincidence of maximum temperature and minimum rainfall is of great importance ecologically. January is everywhere the coldest month, while most stations record the highest mean monthly temperature in July, but the maximum temperatures are usually registered in the early part of August. The rapid fall of temperature during the autumn months is noteworthy. June, July, and August are almost without rain over much of the country, and with the exception of the west coast and the Ionian islands there is very little in May and September. December is as a rule the wettest month, though in some parts of the mainland November shows the heaviest precipitation. 80 per cent. of the rain falls in the winter (October to March), and in summer only 1 to 4 per cent. Moreover, since what rain there is in summer falls in heavy storms, it is of little consequence for the vegetation. The greater part of the rain is brought by the westerly and south-westerly winds, and it is the mountainous western coast and the Ionian islands which receive the greatest amounts. Thus Patras has 693 mm., Cephalonia 745 mm., Nauplia 486·75 mm., and Athens only 390 mm. Little snow falls in the lowlands, but a good deal in the mountains. There is practically no fog, but occasional mists cover the mountainous districts in spring, and light early morning mists are common in some districts. Thunderstorms are not numerous and average two to five per month, being most frequent in summer.

2a. **Cyclades.** The temperatures are less extreme than on the mainland, the range between the hottest and coldest months being only 14·5° C. Frost and snow are rare at sea-level, and even in high areas snow only remains for a few days in winter. The summer is cooler owing to the heat being tempered by the often stormy etesian winds. 80 per cent. of the observations made in July show northerly wind trends. The air is moister than on the mainland, and especially strong dews occur on the northern sides of the islands, which seem somewhat damp even in summer. The general rainfall, as in Greece proper, is in the winter, and is brought by southern winds. The annual rainfall is somewhat greater than on the east coast of Greece, and violent squalls are not uncommon.

The mean monthly average temperatures for four of the islands (Andros, Syra, Naxos, and Santorin) range from 26·7° C. in July to 11·4° C. in January. The highest monthly maximum recorded is 34·8° C. for Syra in July, the lowest being 16·5° C. for Santorin in January; the highest mean monthly minimum temperature is 20·6° C. for Santorin in July and August, the lowest being 1·7° C. for Andros in

January. The mean monthly rainfall for these islands ranges from 93 mm. in December to 2·2 mm. in July.

3. **Thessaly.** The Thessalian meteorological stations for which I have been able to obtain figures are all situated in the lowlands. For them an essentially Mediterranean type of climate is indicated, that is, there is an approximate coincidence of the dry season with the hot season, but the total rainfall far exceeds that of the eastern side of Greece proper and the monthly range is 50 mm. instead of 66 mm. In other words, there is a slight approach to the Central European type of climate. The high mountain areas (for example, the Olympus massif and the Pindus range) undoubtedly show a still greater approximation to the Central European or even to the Alpine climate, but I am unable to give figures to prove this. I saw the first snow of the winter 1917–18 on the peaks and higher slopes of Mount Olympus on the morning of October 15, but it disappeared during the day, finally coming to remain for the winter on October 24.

4. **Epirus.** Information concerning the climate of Epirus is very scanty and details have only been obtained for Yannina. On the whole the period of least rainfall is the summer, coinciding with the period of highest temperatures. The average temperature for the whole year, however, is less than it is for the more typical Mediterranean areas. Moreover the rainfall is high (1,259 mm.), with the maximum in the autumn and early winter months.

4a. **Corfu.** The island is in an extremely sheltered and favourable position, in the mildest part of the North Temperate Zone, surrounded by a warm sea, and on the west of the mountainous coast of Epirus. Moreover, the meteorological data available refer to the capital town, where these conditions are more emphasized than they are in other parts of the island.

The yearly temperature mean (17·7° C.) is somewhat higher than would be expected for the latitude, and the range between the coldest month, January, and the hottest, July, is only 15·7° C. Although the absolute maximum temperature is 37·5° C., the average for the hottest month is 25·8° C., and the summer heat is often oppressive to human beings. This hot period coincides with a period of very little cloud formation (12–15 per cent.) and with the dry season. The hot, dry, Sicilian type of scirocco is of the very rarest occurrence. The mildness of the winters is remarkable and the thermometer very rarely sinks below zero (only so recorded twice in 11 years by Dabovitch). In years in which the temperature at Corfu did not reach zero, the thermometer at the more southern stations of Patras, Athens, and Smyrna registered down to −7° C. The absolute minimum recorded for Corfu is given as −5° C. Snowfall is rare, though the mountains of the

opposite mainland have their peaks covered with snow each winter from the middle of November to the middle of March. In winter the temperature may change rapidly with a change of wind or clouding, and this is the worst feature of the climate. Most of the winds are naturally sea-winds and extreme dryness of the atmosphere is rare, while the fluctuation of this climatic factor is slight. The winter rainfall is very clearly marked, lasting from the end of September to the end of March, while from April to July the rainfall regularly decreases. The total yearly rainfall of 1,314 mm. is quite high. Southern winds, especially from the south-east, are common in winter (modified scirocco), and north winds (maestro) in summer.

5. **Albania.** The influence of the Mediterranean upon climate diminishes eastwards and north-eastwards from the Adriatic. The existence of a permanent trough of relatively low barometric pressure along the line of the Adriatic strengthens the westerly components of the winds along the southern part of the coast, causing air currents of moderate temperature and high humidity to advance inland with greater persistence than farther north. The extent of the penetration of the moist temperate current from the sea depends upon the height and continuity of the mountain barrier. The scirocco and the bora occur, the latter most frequently in the north. The coast is oppressively warm in summer and cold in winter. The contrasts are most pronounced in south Albania. At Valona the mean monthly temperature ranges from 8·9° C. in January to 25° C. in July. Along the coast the rainy season is from the beginning of October to March. The number of rainy days diminishes progressively from north to south. In the dry period there only occur short but sudden and violent rainstorms. At Durazzo 144 mm. of rain have been recorded in December, decreasing to 13 mm. in July; a slightly heavier rainfall is recorded at Valona. In the interior the rainfall is decidedly heavier. Much of the precipitation in the mountains is in the form of snow. In the highlands the winter lasts five or six months.

The distinctive features of the Albanian climate are the extreme cold prevailing in the mountains, the extraordinary variations of temperature, the violence of the winds, and the intensity of the period of drought. Conditions are somewhat mitigated along the valleys between the limestone ranges.

6. **North Macedonia.** The climate of this area approximates very closely to the Central European type. The temperature range is between 23° and 24° C. with a yearly average of 11·8° C. The rainfall varies locally, especially according to altitude and the distance from high mountains, but is fairly evenly distributed throughout the year, with maxima in early summer.

6a. **South Macedonia.** The climate is of a modified Mediterranean type. The hot weather usually commences about the middle of May and continues till September. The summer days are generally cloudless and hazy, and such rain as occurs falls usually during local thunderstorms, which are sometimes severe. July and August are the driest months at Salonica, and July and October at Kavalla, while September is also frequently dry. Long spells of drought, lasting from two to six weeks, may occur at any time during the summer. Thunderstorms are most frequent in May and June, increasing in frequency as one moves inland. During the summer the winds are as a rule light, with marked diurnal variations, but occasionally strong 'Vardar' winds blow. In the inland valleys the temperature is frequently higher than it is on the coast, but the nights are cooler inland, and the atmosphere is less moist. A heat haze is common in the early part of the day in the low-lying districts.

Winter commences towards the end of October. Warm spells generally follow the first cold period and occur at intervals during the winter. From November to March the succession of more or less intense pressure disturbances which affect the Balkan Peninsula, occasion gales, heavy rainstorms, dull drizzling days, or severe frosts, with intervals of fine weather, and mists and fogs are common. The early months of winter are the wettest of the year. The severity of the winter weather increases rapidly as one recedes from the coast, and is especially severe in lofty regions. Falls of snow may occur from November to April, and are heavier and more frequent inland. January is the month of greatest snowfall, and is, in general, the coldest month. The strong, cold Vardar winds are most frequent in January and February, and least so in June. Spring and autumn are both of short duration. The former may be said to cover the months of March and April, and perhaps a part of May, and the latter the end of September and October. The mean annual temperature is, in accord with the latitude, distinctly warm, viz. 15·9° C., the average monthly mean ranging from 26·7° C. in July to 5·6° C. in January. The absolute extremes of temperature recorded are 40·6° C. in August and −9·4° C. in February.

6b. **Athos Peninsula.** Climatically this must probably be considered as part of South Macedonia, but no figures are available.

7. **Thrace.** The climate resembles that of South Macedonia in that it is intermediate between the Central European and Mediterranean types, with the influence of the latter often predominating. It is possible that distinctions should be drawn between the eastern and western parts, and between the coastal and more inland districts, but my data at present are insufficient for the purpose. The records refer to

conditions at Constantinople. Northerly winds predominate, though southerly are frequent. The mean monthly temperatures indicate a mild climate, ranging from 5·2° C. in January and February to 23·6° C. in August. The total annual rainfall of 733 mm. is moderately high. The highest monthly average is in December with 122 mm., and the lowest in July with 27 mm. There is thus an essentially winter rainfall, but the summer drought is less marked, on the average, than it is in Greece. The climate of inland eastern Thrace was sufficiently severe to hold up military action in the first Balkan War (1912), and the Serbs and Bulgars besieged Adrianople in snow. The attempt to acclimatize Australian and New Zealand plants in the cemeteries on the Gallipoli Peninsula has failed for many species because the winters are too severe.

7a. **Thracian Islands.** No detailed information is available, but a few general facts have been culled from different writers who have visited this area. The climate is of the Mediterranean type, with a hot dry summer, and a mild rainy winter. On the other hand, the islands are more affected by the conditions of the mainland, and indeed of South Russia and the Black Sea, than are the more southern islands of the Aegean. This is very evident in the winter, when the wind blowing in on the back of one of the frequent cyclonic depressions brings air from the high pressure reservoir of the cold Russian steppes and from the Balkan and Rodope highlands. The winter winds often arise suddenly. The rainfall is probably between that of Constantinople and Salonica and is mainly in the late winter or early spring.

8. **North Bulgaria.** The climate is of a continental type with hot summers and cold winters, and the rainfall, though heaviest in summer, is distributed throughout the year. There is a general tendency for cold winds to blow from the north during the winter months, while in summer the temperature of south Central Europe is carried over the greater part of Bulgaria. Winter temperatures are low, especially in those regions which are most exposed to the cold northern winds. An absolute minimum of −31·1° C. has been observed at Sofia. The highest temperatures on record are at Sofia 37·2° C. and at Kyustendil 38·3° C. In the Stara Planina temperature varies with elevation, but is also considerably affected by local conditions. Gabrovo at 377 m. altitude, on the northern slope of the range, has a January mean of −1·1° C. and a July mean of 20·3° C.; while Kazanlik, on the southern slope, at an altitude of 400 m., has a January mean of −0·6° C. and a July mean of 21·7° C. The January mean is lower for Lom Palanka (29 m.) and Rustchuk (49 m.) on the Danube, and for Plevna (104 m.) on the Balkan foreland it is −2·2° C. In July, on the other hand, the mean of each of these three places lies between 22·2° and 23·3° C. The

milder winter climate of Varna is probably due to its sheltered position rather than to the proximity of the sea, for in winter the Black Sea is a region of low pressure and the winds are generally offshore.

The rainfall is well distributed throughout the year. On the Balkan foreland the heaviest rainfall takes place in the month of June, while in the basins of Sofia and Kyustendil it occurs in May. A second lower maximum manifests itself either in October or November. The greatest rainfall occurs in the Stara Planina. Thunderstorms are common during the summer months, especially in the mountains. Snowfall is heaviest in the Stara Planina and in the districts round Sofia and Kyustendil.

8a. **South Bulgaria.** This area has more of the Mediterranean type of climate than the last, and is, moreover, protected in its northern parts by the Stara Planina. A study of the isotherms (see *Petermanns Mitteilungen*, 1905, t. 14), shows very clearly the protective influence of this range. Thus the districts around, or near, Stara Zagora have at all seasons of the year a higher average temperature than any other part of Bulgaria, even than the more southern parts around Philippopolis and Khaskovo. The winter conditions are much less severe than in the north. The mean January temperature for Stara Zagora (234 m. altitude) is just above freezing point, and at Khaskovo and Philippopolis just below it. The July temperature is between 22·8° C. and 23·9° C. A maximum of over 37·8° C. is by no means infrequent in August, while in January the thermometer sometimes falls to −17·8° C. The rainfall is fairly evenly distributed throughout the year, with the maximum in June, but the total rainfall is much less than it is for the more western stations of Sofia and Kyustendil. Snow is less frequent than it is in the other areas of Bulgaria. It is possible that the eastern Strandja district is climatically distinct (as it is floristically) from the South Bulgarian plain, partaking of more Caucasian climatic features, but exact meteorological data are entirely lacking. The Strandja range is low, but it runs parallel with the coast and would thus catch the rain-clouds from the Black Sea.

8b. **Rodope Massif.** This includes the highest ground in the Balkan Peninsula, and climatic conditions approach most nearly to those of the Alpine type. Unfortunately exact data are meagre and refer mostly to the Rila Monastery. For this station the mean monthly temperatures range from −2·6° C. in January to 16° C. in July and August. The thermometer may fall as low as −24·4° C. to −28·9° C. in the winter, while the highest summer temperatures recorded are 32·2° C. and 35·6° C. The rainfall totals 777 mm. for the year and is well distributed over all the seasons, with maxima in November and June, and a range of 46 mm. between the driest month, September, and the wettest,

November. The winter snowfall is heavy, and though there is no eternal snow, or glacial formation, snow patches may be found throughout the summer.

9. **Dobruja.** This district, in its climate as in its geographical position, shows a greater relationship with southern Russia than does any other of our divisions of the Balkan Peninsula. The pressure system over Russia is a dominating influence, but the distribution of rainfall is to some extent controlled by the atmospheric conditions which prevail over the Mediterranean area. The temperature mean for the year at Constanța is 11·6° C., at Sulina 11° C., but the range for the months is very high, being for Sulina 24·2° C., with the absolute maximum at 34·9° C. and the absolute minimum at −18·5° C. The lowest monthly mean is in January (−1·7° C.), and the highest in July (22·5° C.) The differences between the absolute maximum and the absolute minimum is 47·2° C. at Constanța and 53·4° C. at Sulina. The total annual precipitation is relatively low, 414 mm. at Sulina, 422 mm. at Constanța, and 435 mm. at Tulcea. The maximum monthly mean for each of these three stations is in June, but there is a fairly equal distribution throughout the whole year, rain falling on an average of 96·5 days at Sulina.

10. **Serbia.** The climate is essentially similar to that of North Bulgaria, that is, distinctly continental. The winter is cold with frequent falls of snow, which lies on the ground for a week or ten days at a time, but disappears about April. The summer is bright and sunny and sometimes extremely hot. Throughout the year the higher valleys are exposed to cold winds from the north and north-east. The monthly mean temperatures show a gradual increase from the winter minimum in January to the summer maximum in July, and a gradual decrease again to December.

10a. **Novi Pazar.** Few figures are available for this region, but the following details have been abstracted from the writings of several travellers. The area is one of climatic extremes, with strong winds of frequent occurrence, and the winter is long and rough, with heavy snowfalls. The rains are spread throughout the year, and in no month does there fall less than 45 mm. of water. Most falls at the end of spring and the beginning of summer.

11. **Montenegro.** The climate varies very considerably between the mountains, valleys, plains, and coastal districts. On the high mountains the snow lies for nearly the whole year; the valleys, on the other hand, have a mild climate, as has also the plain of Lake Scutari. The climate of the coast is like that of Central Italy. Cetinje, at 630 m. altitude, has a mean temperature of −2° C. in January, rising to 22° C. in July. The mean for the year is 11° C. Snow is abundant in winter and often blocks the roads. On the plain by Lake Scutari the mean

monthly temperature ranges from 4° C. in January to 25° C. in July. Only at the northern end of the lake, near Virbazar, does ice occasionally form. Two local winds help to cool the air, the *danik*, blowing in the day from the east, and the *nochnik* in the evening from the north-west. The yearly rainfall is high (2,934 mm. at Cetinje, 771 mm. at Plevlje), with a maximum in October at Cetinje and in May at Plevlje. Thunderstorms may be very violent in the summer months. (The figures for Cetinje are from Hassert, and I am not satisfied with them).

12. **Bosnia.** There are practically only two seasons, summer, lasting from May to October, and winter, which is cold and rather damp, but without fog. Short periods of frost occur, and after the beginning of January the weather becomes severe. The snowfall is not heavy, and except on a few lofty peaks the snow soon melts. The bora is scarcely experienced, but the scirocco, bringing rain from the south-west, is a prevalent wind. The rainfall is abundant and fairly evenly distributed over the year. It increases from the Sava towards the highlands. The mean annual temperature for Sarajevo (altitude 539 m.), which may be taken as representative of the middle Bosnian highlands, is 9·1° C., and for Livno 9° C.

13. **Hercegovina.** The climate contrasts in many respects with that of Bosnia, being of a more Mediterranean type, yet one of great extremes. It is largely exposed to the bora, which is at once cold and violent, coming from the north and sweeping down the lateral valleys of the Dinaric Alps. On the other hand, the heat of summer is oppressive, the temperature often rising above 43° C. The basin of Stolac is said to be the hottest region in the whole of Europe and to have a mean annual temperature equal to that of Jedda in Arabia. In the lowlands, up to 300 m., the mean annual temperature is 4° C. higher than that of Bosnia. The mean for Mostar is 15·2° C., and the maximum 43° C. A minimum of −20° C. has been recorded at Gačko. The rainfall is abundant, especially in the autumn and spring, and increases in quantity with altitude and distance from the coast, but it is very unevenly distributed over the year, the summer being relatively dry. In addition, evaporation from the soil is very active. Under the influence of the bora, the moisture of the air in summer is small (at Mostar 56 per cent.). The heat dries the ground, and the vegetation suffers from lack of moisture.

14. **Dalmatia.** The climate is of three types. First there is that of the northern littoral, which is warm and sunny, but subject to variations from the cold bora, which blows frequently off the mountains. The second is that of the southern littoral, where there is a typical Mediterranean climate. The third is the inland climate, nearly continental and subject to severe frost in winter and heat in summer.

Along the coast the mean temperature in summer is about 23° C.; in winter 8° to 9° C. Inland the mean annual temperature is rather lower, owing to the colder winds. At Knin the mean annual temperature is 13° C., with a variation between the extremes of 11 degrees; this is to be compared with a mean annual temperature at Zara of 15·3° C., and at Ragusa of 16·5° C. Dalmatia is a land of sunshine, and Zara, for example, has annually 800 hours of sunshine more than Vienna, and the differences increase farther south. The winds are of considerable importance. The bora from the Alps, Karst, and Velebit often blows in winter, except in those places protected by their position relative to mountains. The scirocco is the common south wind at Ragusa; often rain-bringing at other times of the year, it is in summer a hot wind, with a peculiar, enervating effect on the human system. The islands have mostly a very equable climate, except where the northern ones are exposed to the bora.

The total annual rainfall gives a high figure for most stations, but varies enormously, from 798 mm. for Lesina, 1,500 mm. for Ragusa, to 4,642 mm. for Crkvice, the last said to be one of the wettest places in Europe. The influence of altitude and position is clearly indicated by a study of the isohyets round the Bocche di Cattaro. The following figures are available for total annual rainfall in this district of South Dalmatia: Castelnuovo (Erceg Novi), 1,717 mm., Cattaro (Kotor) 1,656 mm., Goli Vrh 2,696 mm., Jankov Vrh 4,200 mm., Crkvice 4,642 mm. No detailed figures for rainfall of far inland stations are available, but on and near the coast the maximum monthly rainfall is in the winter, and the minimum in summer.

15. **Croatia.** The narrow coastal belt has an intermediate climate between the Mediterranean and Central European types, but closer to the former, with warm, moist winters and hot, fairly dry summers. The mean annual temperature here is 14° C., that of January 5° C., and of July about 24° C. The inland mountainous parts are mostly decidedly colder, with a mean annual temperature of 5·5° C.; heavy snowfalls occur, the snow lying for a long time. In the Pljesivica district the climate is often rough and cold owing to the frequent occurrence of the long lasting bora with its storms. The spring generally begins in April, the summer is short and hot, and the winter cold, snow generally commencing at the end of October. The rainfall is heaviest in the coastal mountains, where it everywhere exceeds 1,000 mm., being greatest (over 2,000 mm.) somewhat east of Fiume. It is less farther south, but increases again towards the Dalmatian frontier.

16. **Istria and the Karst.** A considerable range of climatic conditions occurs within this area, due partly to differences in altitude but mainly to differences in exposure to or protection from the bora. In

the south of the Istrian Peninsula the bora is scarcely experienced, the summer temperatures are fairly high, the winters mild, and the rainfall (902 mm. per year at Pola) well distributed, with the maximum in early autumn. The Quarnero islands have a very mild climate where protection from the bora is ensured, while the high karst plateau has a much colder winter. Conditions at Trieste are mostly intermediate between those at Pola and those on the Karst, and a study of the figures for mean monthly temperatures shows this very clearly. Observations at Opčina and Basovizza indicate about 1° C. lowering of mean temperature for each 100 m. increase in altitude. The longest record for frost at Trieste is seventeen days (January 11 to 27). The bora is the most prominent feature of the climatic conditions. At Trieste, on an average, it rages 18·9 days in winter, 7·9 in spring, 3·4 in summer, and 8·6 in autumn. The greatest velocity measured in twenty-nine years was 63 m. per second (136 km. per hour), on January 10, 1896. The effect of this wind on the distribution of the different kinds of vegetation is extremely important, and it is, moreover, necessary to remember that its intensity and frequency have probably been increased by deforestation of the karst and mountains. The rainfall over most of the area is considerable (902 mm. at Pola, 1,088 mm. at Trieste). The late summer and early autumn are generally the wettest periods, but no locality can be said to suffer from drought in an average year at any season, in so far as the precipitation is concerned.

Concluding remarks. It is interesting to note that within the boundaries of the Balkan Peninsula occur one of the wettest (Crkvice) and the hottest (basin of Stolac) districts in Europe. Later, in interpreting the relationships of the climate and vegetation, it will be necessary to emphasize that mean, maximum, and minimum figures need very careful evaluation, though when this is carried out they help to explain many phenomena. Local features, not usually apparent in tables of figures, are frequently decisive or limiting factors to some type of vegetation or floristic constituents. Moreover, climatic factors must be considered in conjunction with all others, whether geologic, edaphic, geographic, or biotic, since all interact, modifying, intensifying, or minimizing one another. Thus the Dalmatian coast and the Karst suffer from lack of surface water. Yet the total annual rainfall of portions of the former is one of the highest in Europe, and that of the latter averages 1,000 mm. A partial explanation is that the rainfall is often excessively heavy for a very short period, large volumes of water falling in a few hours, as I have experienced in Montenegro and on the Karst, as well as in South Macedonia. Still more important is the porous nature of the limestone rocks and the absence of a continuous soil or humus covering through deforestation.

The following figures give some idea of the heavy deluges experienced in the Balkan Peninsula in short periods of time:

Place	*Date*	*Time (hours)*	*Rain (mm.)*
Fiume	30 Sept. 1829	8·5	208
Fiume	1–2 Oct. 1898	7·5	268
Fiume	18 Oct. 1898	3·25	222·3
Ragusa	13 Dec. 1872	(1 day)	298
Crkvice	22 Jan. 1897	(1 day)	323
Trieste	14 Oct. 1896	12	154
Pola	3 July 1913	0·3	48
Cara Omer (Dobruja).	17 Aug. 1900	4	320

MEAN MONTHLY TEMPERATURES (CENTIGRADE)

	1 *Canea (Chania)*	2 *Candia (Herákleion)*	3 *Sparta*	4 *Cephalonia*	5 *Zante*	6 *Nauplia*
Jan.	10·8	10·6	9·4	11·0	11·5	10·0
Feb.	10·8	11·1	10·7	11·7	12·3	11·1
Mar.	13·1	12·8	12·3	13·0	13·8	12·5
Apr.	15·7	16·1	15·4	15·5	16·1	15·3
May	19·3	20·0	19·7	18·8	19·7	19·0
June	23·1	23·9	23·7	22·7	23·3	23·3
July	25·7	25·6	27·2	26·3	26·6	26·7
Aug.	25·3	26·1	27·1	25·9	26·4	26·7
Sept.	23·2	23·9	23·6	24·1	24·3	24·0
Oct.	20·3	19·4	19·7	20·6	21·1	20·4
Nov.	15·6	16·1	13·8	15·7	16·4	15·0
Dec.	12·3	12·8	10·4	12·4	13·2	11·8
Year	17·9	18·2	17·7	18·1	18·7	18·0
Range	14·9	15·5	17·8	15·3	15·1	16·7

	7 *Athens*	8 *Syra*	9 *Naxos*	10 *Larissa*	11 *Volo*	12 *Yannina*
Jan.	9·3	11·7	12·6	5·5	7·4	5·0
Feb.	10·3	12·5	12·8	7·6	9·4	6·2
Mar.	11·9	13·5	14·1	10·6	11·7	9·2
Apr.	15·0	16·1	16·4	14·6	14·8	13·5
May	19·3	20·2	19·7	19·2	19·4	19·2
June	23·6	24·1	23·2	24·0	23·7	21·7
July	27·0	26·7	24·9	26·5	26·0	23·8
Aug.	26·9	26·3	24·8	25·7	25·7	24·0
Sept.	23·7	23·4	22·7	22·1	22·1	20·6
Oct.	20·1	21·2	21·2	18·0	19·2	16·3
Nov.	14·2	15·9	16·7	10·3	12·9	9·5
Dec.	11·0	13·2	13·9	7·0	9·7	6·3
Year	17·7	18·7	18·6	15·9	16·8	14·5
Range	17·7	15·0	12·3	21·0	18·6	18·8

MEAN MONTHLY TEMPERATURES (CENTIGRADE) *continued*

	13 *Corfu*	14 *Scutari*	15 *Valona*	16 *Üsküb*	17 *Monastir*	18 *Salonika*
Jan.	10·1	4·1	8·9	−1·4	−1·0	5·6
Feb.	10·9	5·8	9·8	1·2	3·0	7·2
Mar.	12·5	9·6	11·9	7·3	7·5	10·0
Apr.	15·1	14·0	15·2	11·8	11·2	13·9
May	18·7	18·6	18·8	16·7	15·9	19·4
June	22·5	22·4	22·8	20·4	19·5	23·3
July	25·8	25·5	25·0	23·2	22·2	26·7
Aug.	25·6	25·2	24·7	22·3	21·7	25·6
Sept.	23·6	20·9	22·2	19·1	18·5	22·2
Oct.	20·2	16·0	18·4	13·9	13·2	17·8
Nov.	15·4	10·3	13·6	6·1	7·3	11·1
Dec.	11·8	6·6	10·4	1·1	1·9	7·8
Year	17·7	14·9	16·8	11·8	11·7	15·9
Range	15·7	21·4	16·1	24·6	23·2	21·1

	19 *Kavalla*	20 *Constantinople*	21 *Sofia*	22 *Kyustendil*	23 *Philippopolis*	24 *Burgas*
Jan.	5·6	5·2	−3·0	−2·4	−0·5	0·8
Feb.	6·7	5·2	−1·4	1·4	1·2	1·3
Mar.	9·4	7·9	4·0	5·2	6·4	5·3
Apr.	13·9	11·9	10·0	10·4	12·2	10·8
May	20·0	16·9	14·8	16·1	17·2	15·9
June	23·6	21·3	18·4	18·8	21·1	20·2
July	25·6	23·5	20·7	21·0	23·5	23·0
Aug.	26·1	23·6	19·7	20·9	22·5	22·3
Sept.	21·7	20·2	15·9	16·6	18·4	18·8
Oct.	16·7	16·8	11·0	11·6	13·4	14·4
Nov.	11·7	11·8	4·5	4·8	6·9	8·4
Dec.	8·9	7·6	−0·6	1·8	1·8	3·5
Year	15·8	14·3	9·5	10·5	12·1	12·1
Range	20·5	18·4	23·7	23·4	24·0	22·2

MEAN MONTHLY TEMPERATURES (CENTIGRADE) *continued*

	25 *Kazanlik*	26 *Rilski Monastir*	27 *Sulina*	28 *Belgrade*	29 *Kragujevac*	30 *Vranje*
Jan.	−0·6	−2·6	−1·7	−1·6	−1·8	−2·2
Feb.	2·2	−1·2	0·0	1·0	0·7	0·6
Mar.	5·6	1·3	4·1	6·1	5·6	5·8
Apr.	10·6	5·9	9·5	11·1	10·6	10·8
May	16·1	11·5	15·8	16·4	15·8	15·9
June	19·4	13·8	20·1	19·5	18·8	18·7
July	21·7	16·0	22·5	22·0	21·2	21·4
Aug.	21·7	16·0	21·9	21·4	20·4	21·1
Sept.	16·7	12·1	17·9	17·4	16·5	17·4
Oct.	12·1	8·2	13·2	12·9	12·2	12·7
Nov.	5·6	3·2	6·5	5·9	5·5	5·5
Dec.	2·2	0·0	1·7	1·2	0·9	0·7
Year	11·1	7·0	11·0	11·1	10·5	10·7
Range	22·3	18·6	24·2	23·6	23·0	23·6

	31 *Cetinje*	32 *Podgorica*	33 *Sarajevo*	34 *Banjaluka*	35 *Mostar*
Jan.	−1·7	5·5	−2·6	−0·7	5·4
Feb.	1·0	6·9	−0·5	1·4	6·6
Mar.	5·0	8·9	4·0	6·0	9·7
Apr.	10·3	15·6	9·5	11·4	14·0
May	15·6	21·3	13·9	15·8	18·4
June	19·3	24·5	17·2	19·3	22·8
July	22·0	26·3	19·4	21·3	25·7
Aug.	21·3	25·6	19·0	20·5	25·6
Sept.	17·0	20·0	15·4	16·5	21·5
Oct.	11·9	13·1	10·6	11·8	16·1
Nov.	5·6	9·3	4·2	5·7	10·3
Dec.	1·1	5·6	−1·1	0·8	6·3
Year	10·7	15·4	9·1	10·8	15·2
Range	23·7	20·8	22·0	22·0	20·3

MEAN MONTHLY TEMPERATURES (CENTIGRADE) *continued*

	36 *Ragusa*	37 *Lesina*	38 *Zara*	39 *Fiume*	40 *Abbazia*
Jan.	8·7	8·6	6·7	5·95	5·3
Feb.	9·4	9·0	7·3	7·01	5·9
Mar.	10·9	11·1	9·7	9·32	8·2
Apr.	14·1	14·3	13·7	14·00	12·7
May	18·1	18·3	18·1	18·30	16·7
June	22·2	22·3	22·3	23·00	20·4
July	25·0	25·1	25·0	24·90	22·9
Aug.	24·8	24·6	24·4	24·93	22·3
Sept.	22·3	21·7	21·2	20·46	18·9
Oct.	18·4	18·1	16·6	16·92	14·5
Nov.	13·4	13·2	11·1	10·60	9·4
Dec.	10·2	9·7	7·7	7·16	6·2
Year	16·5	16·3	15·3	15·20	13·6
Range	16·3	16·5	18·3	18·98	17·6

	41 *Pola*	42 *Lussin-piccolo*	43 *Trieste*	44 *Karst Edge*	45 *Divaccia (plateau)*
Jan.	5·4	7·4	4·1	1·7	−1·1
Feb.	5·9	7·7	4·9	2·7	0·3
Mar.	8·1	9·4	7·7	5·5	3·7
Apr.	12·7	13·5	12·4	10·8	8·8
May	16·8	17·8	16·4	14·5	13·1
June	21·2	21·9	20·7	18·8	17·2
July	24·0	24·6	23·0	21·1	19·3
Aug.	23·3	24·2	22·4	20·3	18·5
Sept.	19·6	21·0	19·1	16·8	14·9
Oct.	15·0	16·7	14·5	12·0	10·2
Nov.	9·8	11·7	9·1	6·4	4·4
Dec.	6·2	8·5	5·4	2·7	0·1
Year	14·0	15·4	13·3	11·1	9·1
Range	18·6	17·2	18·9	19·4	20·4

MEAN MONTHLY RAINFALLS (MILLIMETERS)

	1 *Canea (Chania)*	2 *Candia (Herákleion)*	3 *Cephalonia*	4 *Patras*	5 *Athens*	6 *Santorin*
Jan.	105	86	118	85	52	71
Feb.	100	82	110	69	37	38
Mar.	45	50	76	59	34	35
Apr.	20	16	42	50	21	29
May	10	12	28	40	20	19
June	6	2	21	16	17	1
July	0	3	4	1	7	0
Aug.	2	9	5	10	9	0
Sept.	8	20	29	28	14	6
Oct.	24	46	85	92	44	19
Nov.	171	91	104	106	73	69
Dec.	143	101	123	137	62	82
Year	634	518	745	693	390	362
Range	143	99	119	136	66	82

	7 *Larissa*	8 *Volo*	9 *Yannina*	10 *Corfu*	11 *Skutari*	12 *Valona*
Jan.	45	43	140	159	118	101
Feb.	46	45	98	151	152	87
Mar.	42	46	144	110	168	105
Apr.	40	33	72	76	126	54
May	48	36	48	54	83	40
June	33	26	72	22	53	45
July	31	13	38	5	39	13
Aug.	19	17	51	23	26	48
Sept.	27	30	39	90	88	90
Oct.	48	43	175	161	188	155
Nov.	69	67	181	216	215	202
Dec.	59	55	201	247	158	149
Year	507	454	1,259	1,314	1,414	1,089
Range	50	54	163	242	199	189

MEAN MONTHLY RAINFALLS (MILLIMETERS) *continued*

	13 *Üsküb*	14 *Monastir*	15 *Salonika*	16 *Kavalla*	17 *Constanti-nople*	18 *Sofia*
Jan.	36	49	37	71	87	38
Feb.	28	67	36	87	69	36
Mar.	20	50	41	69	62	37
Apr.	43	63	48	49	42	52
May	58	73	60	52	30	86
June	57	70	44	42	34	82
July	37	46	25	18	27	69
Aug.	37	45	31	55	42	54
Sept.	30	35	40	34	52	49
Oct.	53	86	53	22	64	62
Nov.	38	76	69	69	102	49
Dec.	50	66	61	82	122	36
Year	487	726	545	650	733	650
Range	38	51	44	69	95	50

	19 *Kyustendil*	20 *Philip-popolis*	21 *Burgas*	22 *Kazanlik*	23 *Rilski Monastir*	24 *Sulina*
Jan.	49	48	47	44	48	28
Feb.	48	46	57	46	62	21
Mar.	31	41	41	37	55	30
Apr.	45	47	45	44	79	33
May	72	43	51	70	79	34
June	60	67	86	95	85	56
July	60	42	40	57	61	34
Aug.	60	31	30	38	54	26
Sept.	38	34	22	45	41	43
Oct.	55	32	51	53	78	41
Nov.	64	45	64	63	87	40
Dec.	43	34	52	43	48	28
Year	625	510	586	635	777	414
Range	41	36	64	58	46	35

MEAN MONTHLY RAINFALLS (MILLIMETERS) *continued*

	25 *Belgrade*	26 *Plevlje*	27 *Cetinje*	28 *Sarajevo*	29 *Travnik*	30 *Mostar*	31 *Ragusa*
Jan.	29	49	228	59	71	97	177
Feb.	33	49	268	56	64	87	122
Mar.	45	60	362	77	79	127	137
Apr.	57	62	406	59	70	149	125
May	72	70	147	69	78	88	84
June	80	92	93	78	79	75	64
July	70	62	20	59	75	49	36
Aug.	45	48	28	63	56	42	70
Sept.	44	62	200	72	66	100	97
Oct.	60	90	309	102	91	170	190
Nov.	43	63	486	77	66	129	205
Dec.	41	64	387	71	71	122	193
Year	619	771	2,934	842	866	1,235	1,500
Range	51	44	466	46	35	128	169

	32 *Lesina*	33 *Crkvice*	34 *Zengg*	35 *Fiume*	36 *Pola*	37 *Trieste*	38 *Lussin-piccolo*
Jan.	75	476	72	95	56	61	80
Feb.	66	471	71	99	49	57	58
Mar.	71	497	80	127	70	71	90
Apr.	57	459	90	127	74	79	78
May	41	277	94	123	71	97	60
June	36	157	105	138	72	101	71
July	21	66	52	72	44	77	35
Aug.	39	68	93	107	68	89	67
Sept.	69	244	134	182	92	123	102
Oct.	101	565	192	238	124	156	148
Nov.	115	683	165	174	91	104	117
Dec.	107	679	120	136	91	73	102
Year	798	4,642	1,268	1,618	902	1,088	1,008
Range	94	617	143	166	80	99	113

MEAN MONTHLY RELATIVE HUMIDITY PER CENT.

	1 *Canea (Chania)*	2 *Candia (Herákleion)*	3 *Cephalonia*	4 *Patras*	5 *Athens*	6 *Santorin*
Jan.	76	69·0	77·3	75·2	74·0	72·3
Feb.	75	69·0	78·0	74·3	72·0	71·7
Mar.	72	68·0	76·5	71·0	69·2	70·7
Apr.	70	64·0	75·7	70·8	64·4	70·6
May	67	63·0	73·9	69·7	59·7	69·6
June	61	61·0	72·1	68·0	54·2	65·4
July	58	61·0	68·7	61·6	47·0	60·4
Aug.	57	60·0	70·9	60·3	46·3	62·1
Sept.	62	65·6	71·5	63·7	55·0	68·2
Oct.	67	68·0	77·9	71·2	66·0	72·5
Nov.	74	68·0	79·1	73·2	73·3	73·7
Dec.	76	73·0	80·8	75·4	74·5	74·6

	7 *Larissa*	8 *Volo*	9 *Corfu*	10 *Durazzo*	11 *Salonika*	12 *Kavalla*	13 *Constantinople*
Jan.	79·3	74·5	76·1	77	70·8	84	74
Feb.	75·8	73·0	78·3	74	71·3	85	71
Mar.	71·3	71·1	75·0	73	68·3	83	62
Apr.	66·7	70·1	75·5	72	66·1	83	57
May	62·1	65·2	73·7	73	64·3	81	57
June	55·2	65·6	72·8	71	60·7	79	53
July	49·5	63·4	68·8	68	54·2	75	53
Aug.	48·6	60·7	68·4	71	57·0	75	53
Sept.	58·3	65·1	71·8	73	62·4	78	55
Oct.	72·3	74·3	78·6	78	71·0	82	63
Nov.	70·1	76·6	77·5	79	73·6	84	71
Dec.	81·7	73·8	78·0	80	74·5	85	74

MEAN MONTHLY RELATIVE HUMIDITY PER CENT. *continued*

	14 *Sofia*	15 *Kyusten-dil*	16 *Philip-popolis*	17 *Burgas*	18 *Kazanlik*	19 *Rilski Monastir*	20 *Lussin-piccolo*
Jan.	82	77·5	78·0	80	77	72·0	74
Feb.	79	75·4	79·5	83	75	71·4	72
Mar.	72	69·0	73·0	81	69	71·4	74
Apr.	66	61·7	65·0	77	63	67·5	71
May	66	60·3	67·5	79	64	70·6	69
June	68	63·7	65·5	77	66	70·2	68
July	63	59·2	58·5	74	57	66·0	64
Aug.	62	56·5	58·0	72	54	63·3	66
Sept.	68	64·0	65·0	75	63	70·7	72
Oct.	77	75·0	73·5	81	73	76·0	76
Nov.	81	78·2	79·5	82	78	78·0	75
Dec.	83	80·2	81·0	84	79	79·4	74

HYDROTHERMIC GRAPHS (pp. 66–68)

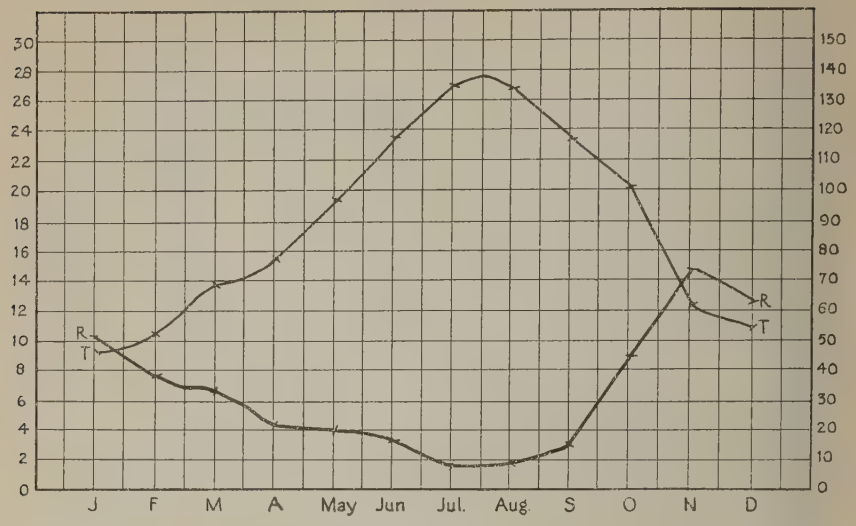
Six pairs of graphs are given below to illustrate, in a much clearer manner than can be done with tables of figures, the seasonal relationship of temperature and rainfall in as many districts. The abscissae represent the months, the ordinates for temperature are marked on the left of the graph in degrees centigrade, and those for rainfall in millimeters on the right. In every graph-pair the line marked T is the graph for temperature and the line marked R that for rainfall. The significance of the coincidence or otherwise of the maxima and minima for the mean monthly temperature and rainfall is emphasized in the text of this chapter.

PALAEOMETEOROLOGY

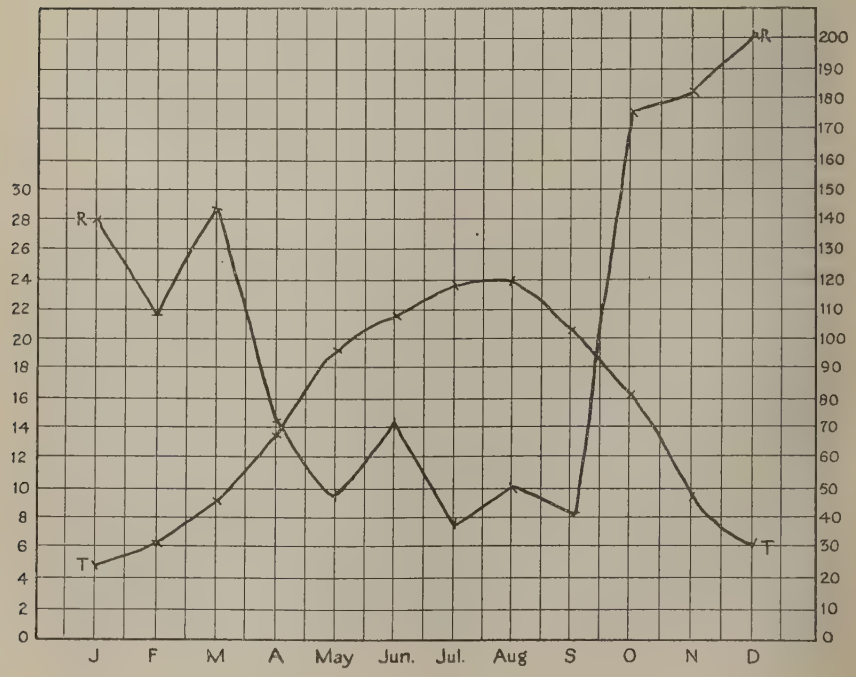
There is no doubt that if reliable details concerning the climates of past ages in our area were available they would help in the interpretation of many a puzzling problem in the phytogeography of the Balkan Peninsula. Unfortunately the bulk of the published work expresses theoretical opinions, scarcely any of which have not been controverted by other writers on the subject. There is undoubtedly here an almost untouched field for research. It is probable that an inductive study of the numerous fossil plant-beds in the Balkan Peninsula will yield more reliable data than the deductions of physicists, however difficult it may be to reconstruct past climates from palaeontological evidence. If modern methods of the study of Quaternary and Tertiary fossil plants, by the detailed examination and comparison of fruits and seeds, anatomical studies of cuticles, and microscopic examination of pollen-grains, could be applied to collections made in the Balkan Peninsula

 (*to p. 69*)

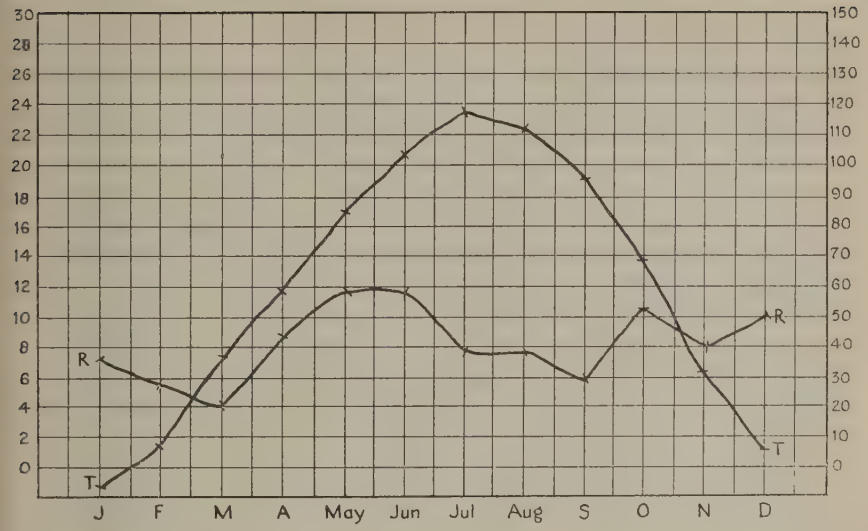
ATHENS



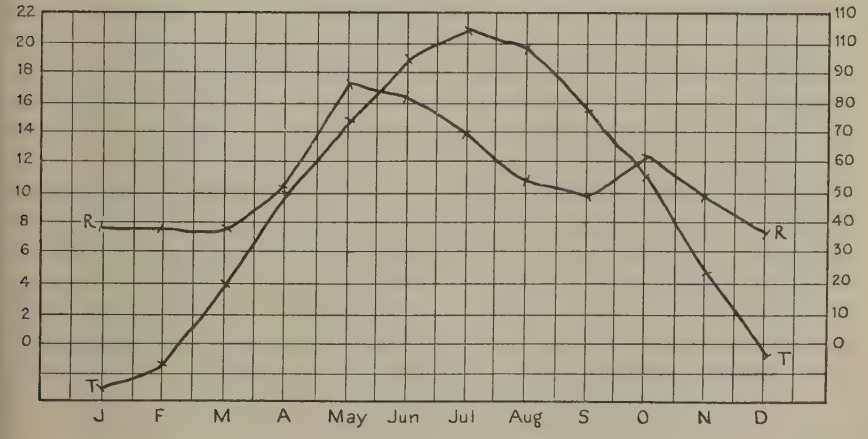
YANNINA



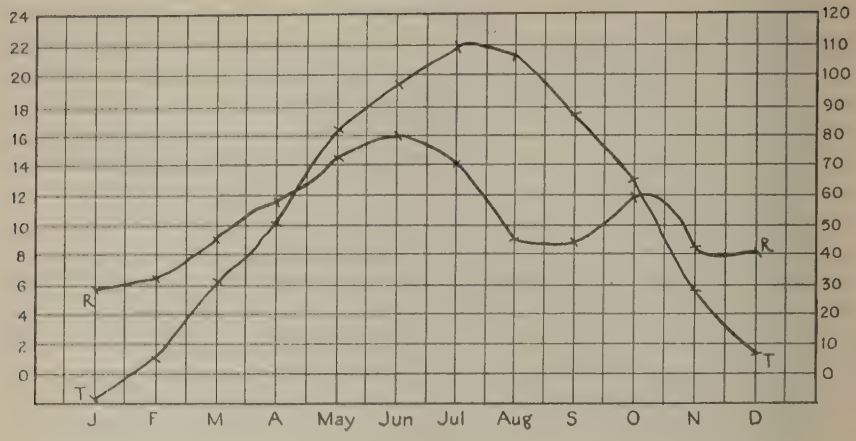
ÜSKÜB (Skoplje)



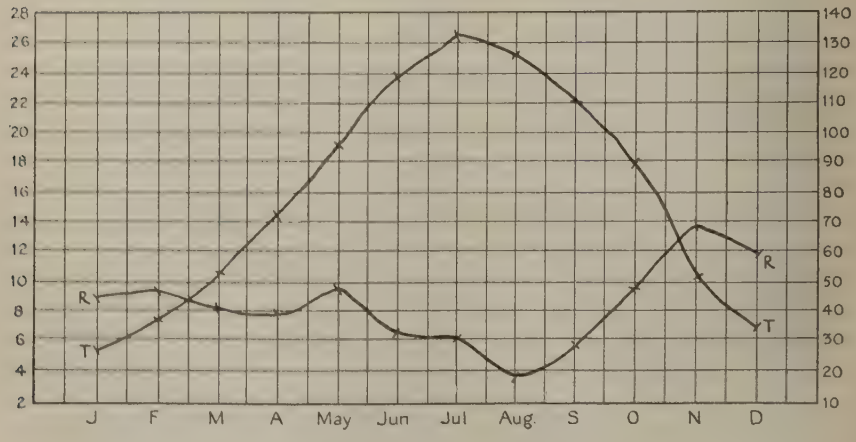
SOFIA



BELGRADE



LARISSA



results would be obtained of value to all students of the European and Oriental floras, indeed to all geobotanists. The study of the Glacial period in the Balkan Peninsula has made considerable progress in recent years, and certain facts concerning it seem to be established. Isolated papers on the fossil floras of different places have been published, but they are all based mainly or entirely on the unsatisfactory work of matching, by macroscopic examination, impressions—generally of leaves only—with herbarium material of existing genera. Few of the determinations can be relied upon, and, though it is necessary to consider them briefly in the present connexion, I stress no details given by the authors. Suggestions derived from a study of a few fossil faunas are also included.

Evidence from Tertiary floras. Visiani (1858) has described a fossil flora chiefly from Mount Promina in Dalmatia, said to be of Eocene Age. Floristically the list indicates great differences from the existing vegetation. Thus what are now southern genera of *Proteaceae* and *Myrtaceae* are included in it. On the other hand, the flora as a whole cannot be described as either more tropical or more temperate than that which now flourishes in Dalmatia. Pax (1921) has given details concerning fossil plants obtained from Neogene sands and marls in the neighbourhood of Skoplje (Üsküb) in North Macedonia. The flora, which is most probably of Miocene Age, represents the remnants of a forest vegetation, and indicates a climate corresponding to that of temperate Eastern Asia or temperate North America. In general the flora was like that of the rest of Europe in later Tertiary times, and was not more tropical than that of Central Europe was then. H. Engelhardt (1903, 1904, 1909, 1912) and F. Katzer (1903) have described a number of fossil floras from Bosnia. These are of different ages (not always exactly determined) from Oligocene to Lower Pliocene, and show a mixture of genera now found in the Balkan Peninsula with others characteristic especially of North America and Eastern Asia, and a few now essentially tropical. The flora of the Brown Coal beds near Foča in south-eastern Bosnia is lacking in australoid types and in those whose recent representatives would indicate a tropical climate. The numerous species with deciduous leaves may indicate a climate with precipitation and temperature showing less extremes than those of the existing climate.

The fossil fauna of Pikermi is well-known and is of great interest because of its probable African affinities. Smith Woodward (1901) examined a similar fauna in Euboea. The age of the beds has been variously considered as Lower Pliocene or Upper Miocene, but Unger (1862, 1867) who studied the associated flora of Kumi in Euboea says the plants are of Middle Miocene rather than of Upper Miocene Age,

and are certainly not Lower Pliocene. Most of the plants had small, oval, elliptic, lanceolate, or linear leaves, and large broad leaves are absent. Most are hard and leathery and indicate on the whole a climate very like that of the present in Greece but probably somewhat warmer and with little alternation of hot and cold conditions.

There are numerous deposits with fossil plants in Bulgaria but, so far as I have been able to ascertain, they have never been properly studied. There are two or three collections at the Natural History Museum, South Kensington, awaiting determination. The Tertiary coal beds of Pernik, in western Bulgaria, should yield an interesting fossil flora. In July 1926 in Sofia I saw a collection of fossils from a Pliocene deposit near the capital. The following genera were represented in it: *Abies* (cone-scales and leaves), *Quercus*, *Zelkova*, *Picea*, *Pinus*, *Fraxinus*, and *Acer*, and a specimen which may be *Prunus laurocerasus*.

The very meagre and unsatisfactory data referred to above appear to indicate that through much of the Tertiary epoch, up to Lower Pliocene times, the climate of the Balkan Peninsula was not markedly different from what it is now, except that it may have been as a whole more uniform over the entire area and with less marked seasonal differences. Though floristically of a very different composition the vegetational types—sclerophyllous, deciduous, &c.—were then not unlike those now found in the Peninsula.

Glacial period. We have now to consider the Quaternary Ice Age as it affected the Balkan Peninsula. It was for many years believed that the whole of the region was unglaciated when Northern and Central Europe was covered with ice-sheets. The studies of Cvijić and other geologists and geographers have shown this view to be erroneous. We now know that in the Ice Age many of the higher mountains of the Balkan Peninsula had glaciers, though at present no part is above the climatic permanent snow-line. The clearest evidence of glaciation is found in the Rila mountains (Cvijić 1898). Corries, moraines, roches moutonnées, and high mountain lakes were discovered, described, and mapped. Cvijić (1900, 1901) extended his studies to Bosnia, the mountains of Hercegovina, and Montenegro, and found traces of glaciation in many places. The following table indicates the position of the mountains examined in most detail, and gives the altitude of their snow-lines in the Ice Age.

	Distance now from west coast	*Snow-line in Ice Age*
	km.	m.
Orjen	15	1,400
Prenj Pl.	70	1,680
Treskavica Pl.	100	1,780
Rila Pl.	330	2,200

These figures show that on the west coast of the Balkan Peninsula, between 42·5° and 43·5° N., the snow-line lay at about the same altitude as in Norway, between 60·5° and 61·5° N., to-day.

Cvijić also described corries and a corrie lake in the Shar Planina (Scardus) but found no moraine, and no traces of glaciation were known for the Greek mountains, for Smolika, and the Thessalian Olympus. Similarly the Vitoša and western Stara Planina showed no signs of glaciation. The Macedonian Peristeri has small lakes whose basins may be of glacial origin, and Pirin was certainly glaciated. In all the above mountains the glaciers were relatively small and generally on one side only. Orjen had ice all round, but the other heights showed moraines and corries only on their north and east sides. More recent investigations show that for some other areas, such as Durmitor, this view has to be modified. There is no evidence that glaciers flowed anywhere from the mountains to the lowlands or coast.

Vasović (1908) has described traces of the Ice Age in Serbia, especially in the Kopaonik and Jastrebac mountains. Cvijić (1913) considers parts of the upper Ibar district (NW. of Pech) to have been glaciated (Rozaj basin), also the districts of the Pečska Bistrica, the Upper Lim, Komovi, and the Bjelastica (SW. of Andrijevica and NE. of Kolašin), Kuć (NE. of Podgorica), Durmitor, and others in Montenegro. Evidence of glaciation was found by Roth v. Telegd (1925) for the districts of Plava and Gusinje. Niculescu (1915–16) showed that the presence of two cirques and a glacial lake indicated the former existence of local glaciers in the massif of Smolika. Dedijer (1916–17) found moraines, cirques, and roches moutonnées in mountains on the Albanian–North Macedonian frontier—Stogovo, Jablanica, and Mali Kuć (Crvena Planina). For Jablanica he fixes the altitude of the old snow-line at 1,400–1,500 m., for Stogovo 1,890 m., and for Mali Kuć about 1,900 m. Almagià (1918) has also described glacial traces in Albania. F. Doflein (1921) refers to glacial traces in the Golesniza Planina in North Macedonia. B. Milojević (1922) has recorded glacial traces in the mountains of Vlasulja, Broč, and Kručica. Krebs (1922) refers to glacial phenomena in the Kopaonik mountains.

Except that Cvijić (1908) refers to corries (Kare) on the Thessalian Olympus, I have found no record of glaciation on this massif. Maull (1922) refers to glacial traces on the higher mountains (Taygetos, Chelmos, Ziria, Parnassus, Giona, Vardussia, Olympus), but I have been unable to find any researches on which the statement could be based.

It is evident that all the glacial traces in the Balkan Peninsula indicate only local glaciation of the high mountains. There is no suggestion of a great ice-sheet such as that of the north of Europe, nor of such

continuous ice-masses as were present in the Alps and Pyrenees. It is very probable that some of the mountains which now show the most marked traces of glaciation (e.g. Orjen) were then of a greater altitude than they are now and that the snow-limit on them was higher than is now apparent. It is otherwise difficult to account for the fact that many mountains as high as these are now, show no traces of ice action.

In considering the effects of the Ice Age on the Balkan Peninsula there are three direct results which concern us here: the lowering of the temperature, the increase of the rainfall and a modification of its seasonal distribution, and the formation of new soil types. There can be no doubt that the temperature, of the central and northern parts especially, was much lower than that of the Tertiary period and that of to-day. It has already been pointed out that the snow-line in the Ice Age was apparently about the altitude it is to-day in South Norway. If, however, it has to be allowed, as Cvijić insists it must be, that the glaciated mountains were in the Ice Age higher than they are now, then we must judge that the climate of the bulk of the Peninsula was somewhat milder than that of South Norway is to-day. On the other hand the Greek Peninsula, apart from Crete, stretches five degrees south of the line of definitely glaciated mountains, and is, moreover, sea-girt. There was thus not only much ice-free lowland available for vegetation during the Ice Age but also a considerable warmer area to the south.

Increased rainfall. There is some evidence that during the Ice Age the rainfall in the Eastern Mediterranean area was greatly increased in volume and intensity, so that the term Pluvial period has been used. Brooks (1922) says 'with an ice-sheet storms will increase in frequency and their tracks must be crowded together on the equatorial side of the ice-sheet.... Hence, when an ice-sheet covered Northern and Central Europe the Mediterranean region must have had a marked increase of storminess with probably rain in summer as well as in winter,' though the latter still had more than the former. The details of the Pluvial period have been worked out more in the Sahara and Red Sea hills than elsewhere, but some evidence is obtainable in the Balkan Peninsula, where there are many deposits of a 'diluvial' character. In a previous work on South Macedonia I refer to some I examined in 1917. Cvijić (1910) mentions the diluvial conglomerates of the slopes of the Thessalian Olympus. The occurrence of *Rhododendron ponticum* in tufa of probably Quaternary Age in the island of Scyros would indicate a wetter climate than is now characteristic of the Aegean [Turrill in *Gard. Chron.* lxxv. (3rd. series) 378 (1924)], but after a careful examination of the specimens at the Natural History Museum, South Kensington, I am convinced that their identification is incorrect. We can

conclude then, that on the whole the Ice Age was a wetter period in the Balkan Peninsula than the present, and that the retreat of the North European ice-sheet led towards a warmer and drier climate, a change especially for the summers of the Mediterranean parts.

Soils resulting from glacial phenomena. As regards the formation of new superficial beds we are sure there is nothing in the Balkan Peninsula comparable with the Boulder Clays of North Europe, and apart from very local morainic deposits and the diluvial beds referred to above we have only to mention the loess. A considerable extent of country in the Dobruja and North Bulgaria is covered by loess directly connected in origin with the loess of Southern Russia. It is generally agreed that this has been produced by fine wind-borne (aeolian) materials immediately before, during, or immediately after the Ice Age. The loess is now largely covered by a steppe-like vegetation, but this is only partly due to the soil characteristics. It is probable that the loess in our area was produced when the climate was Aralian in type (Martonne)—a dry climate with some rain in spring and great extremes of temperature. It is probable that the climate has become somewhat wetter than it was when the loess was deposited, and in the south of the Dobruja forest has even invaded the domain of arid steppe.

Indirect effects of the Ice Age. The indirect effects of the Ice Age on the Balkan Peninsula were very great and of special importance in the history of the vegetation. An examination of a map of the distribution of inland ice in Europe during this period (as that in Wright's *Quaternary Ice Age*, 1914, opposite p. 103) shows that the Balkan Peninsula is farther removed from the edge of a large glaciated region than were the Italian and Iberian peninsulas, and that, unlike these, it was not cut off from Central Europe by ice-fields stretching east and west. The idea of the Balkan Peninsula as a land of refuge for pre-glacial Central European types is plausible. Moreover, since the Dinaric Alps link up fairly closely with the Eastern Alps proper, and perhaps in glacial times the connexion was more pronounced than it is now, the Balkan Peninsula could have harboured so-called 'alpine' species which would not otherwise have survived. It is also important to remember that the glaciation of the Eastern Alps and of the Southern and Eastern Carpathians was less extreme than that of the Central and Western Alps.

It is well-known that there has been a considerable controversy among geologists as to whether the Ice Age resulted in a single, double, fourfold, or manifold glaciation. It is probable that the smaller ice-sheets responded to slighter climatic changes than the great sheet of North Europe, and the evidence for from four to six glacial periods with mild interglacial periods between them seems well

established for the Alps. Cvijić (1914) has given evidence in favour of the view that there were two glacial periods in the Balkan Peninsula—a younger, less extensive one, nearly corresponding to the Würm period of the Alps, and an older one more extensive than the present glaciation of the Alps.

It is important for our phytogeographical studies to consider the relative dates of the Ice Age and the formation of the Aegean Sea. This latter phenomenon is considered in some detail in the chapter on Geology. There is no doubt that during a considerable part of the later Tertiary (Neogene) epoch Europe and Asia were united across what is now the Aegean Sea. The southern parts of this Aegean land fractured and foundered first, allowing the penetration of the fourth Mediterranean transgression up to the line of the Cyclades and the Dodecanese. Lastly the whole Aegean continent foundered and the Mediterranean penetrated far into the Pontic basin. This phenomenon took place in a very recent epoch, certainly since the glacial period, and perhaps man witnessed it (Suess).

Post-glacial climates. The question of post-glacial climates is a debatable one. On the one hand Kropotkin, Huntington, Petterson, Brooks, and others have held that considerable fluctuations or modifications of climate are traceable in natural phenomena or historical documents since the Ice Age. In opposition to this Nansen, J. W. Gregory, and others hold that the climate has been fairly uniform, at least within historic times. With the broader aspects of the question we are not here concerned. The evidence for marked recent climatic changes in the Balkan Peninsula is not strong, and supposed detailed evidence is usually susceptible of another explanation—as for example the burial of Olympia. Often it is difficult to separate cause and effect, as in forest destruction. In dealing with vegetation one has always to consider the final valuation of all interacting causes. Thus forests once destroyed may naturally regenerate under one type of climate on one type of soil, but fail to do so entirely under other climatic and edaphic conditions. Vegetation may not modify climate but it certainly modifies the reaction of climate on man, and much of the supposed evidence of climatic changes in history can be explained on this basis. I have not found it necessary or advisable to postulate recent climatic changes in the Balkan Peninsula. One very striking argument is based on the dates of the sowing and reaping of wheat in ancient and modern times. Hesiod gives precise astronomical indications for Boeotia, and his statements have been interpreted as meaning that wheat should be sown between October 20 and November 25, and harvest should commence on May 15. According to the Ministry of Agriculture in Greece, sowing begins in Boeotia to-day during the last twelve days of

October, and the middle of May is the normal time for the cutting of the crop. So close a correspondence seems to indicate that rainfall and temperature conditions have not altered materially in the interval.

Sir Napier Shaw has reached very similar conclusions. Thus he sums up on p. 95 of his *Manual of Meteorology*, vol. i. (1926) in the following words:

'Hence we may conclude that in spite of modifications of the atmospheric circulation which have resulted in diminished rainfall and consequently had great effects from time to time upon civilization in the Mediterranean regions, the general features of the circulation of air over the region from 22° N. to 52° N. have not changed and the sketch of the climate which we gave in chapter II, with modifications in normal values, may be taken as expressing the relative characteristics of the circulation known to the ancients, the seasons are the same and the crops are still mainly the same and require the same cycle of seasons, though the area over which they can be profitably cultivated may have been considerably reduced and some of the region may have been transformed from habitable land into inhospitable desert.

'. . . at the moment the quantitative evidence of change is of the nature of minor fluctuations rather than of sweeping modifications.'

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Total annual rainfall (*generalized*)

IV

DURATION AND LIFE-FORMS OF BALKAN PENINSULAR PLANTS

THE SYSTEMS USED

The classification of plants into trees, shrubs, and herbs is an ancient and relatively simple method of recording vegetation for any area. It is still of recognized importance for certain ecological and phytogeographical purposes, and the species of the Balkan Peninsular flora have been tabulated on this basis, using the following symbols: ħ tree, ħ shrub (including liane), 4 perennial herb, ② biennial herb, and ① annual herb. The results are here given for each family.

This classification is however insufficient for many purposes, and others giving more data have been proposed. Several of these are summarized by Clements (1920). Chief amongst them is the life-form classification elaborated by Raunkiaer (1905). This I have found of considerable interest and usually as definite as any similar classification is likely to be. Most species can be placed without difficulty in one of Raunkiaer's categories though some overlap into two. Succulents are almost absent in the Balkan Peninsular flora, excepting some of the species of *Sedum* and *Sempervivum*, which might be listed as leaf-succulents; also there are no specially adapted epiphytes. I have, therefore, not included these categories. A slight modification has been made in Raunkiaer's scheme in counting the biennial herbs as hemicryptophytes or, more rarely, as chamaephytes. The following letters are used to designate the classes[1]: **MM** mega- or mesophanerophytes, **M** microphanerophytes, **N** nanophanerophytes, **Ch** chamaephytes, **H** hemicryptophytes, **G** geophytes, **HH** helophytes and hydrophytes, and **Th** therophytes.

Raunkiaer's system has been adversely criticized because it is based almost entirely on the position of the perennial buds during the unfavourable period or periods and is thus to a large extent artificial, since other biological characters are ignored. I have therefore drawn up and used an extended scheme for the Balkan Peninsular flora. It

[1] The *phanerophytes* have their dormant buds on branches which project freely into the air; the *megaphanerophytes* have a stature over 30 m., the *mesophanerophytes* from 8 to 30 m., the *microphanerophytes* from 2 to 8 m., and the *nanophanerophytes* are less than 2 m. high. The *chamaephytes* are plants with their buds or shoot-apices perennating on the surface of the ground or just above it. The *hemicryptophytes* have their dormant buds in the upper crust of the soil, at or just below the surface. The *geophytes* have their dormant parts subterranean, and the *hydro-helophytes* have aquatic or semi-aquatic dormant buds. *Therophytes*, or plants of the favourable season, live through the unfavourable season as seeds.

must be clearly understood that this scheme is intended solely for the specific purpose of an analysis of the flora of the Balkan Peninsula, and is capable of indefinite modification. Its use has, however, yielded numerous interesting results which are discussed below. For tabulation purposes the following figures have been used as symbols: 1, Evergreen tree; 2, Deciduous tree; 3, Evergreen shrub; 4, Deciduous shrub; 5, Woody liane or sprawler; 6, Switch plant, leafless, or nearly leafless; 7, Plant with spines, thorns, or strong prickles; (8, Dwarf shrub); 9, Perennial herb or under-shrub, partially woody at the base and the aerial parts dying back but not to ground level; 10, Grass or grass-like plant; 11, Rush or sedge form with suppressed, or nearly suppressed, eaves; 12, Perennial herb or under-shrub with runners or sprawling or ascending herbaceous or suffruticose stems; 13, Cushion plant; 14, Rosette plant; 15, Herbaceous climbing plant, generally dying down each year; 16, Perennial herb dying down yearly, with perennial buds on more or less thick stock at ground level; 17, Geophyte; 18, Therophyte; 19, Hydrophyte; 20, Parasite or saprophyte. It is obvious that many plants will find place in more than one category, and therophytes have been counted under 18 as well as under any other group to which they may belong. For the purposes intended this is no objection. It was found that category 8 was unsatisfactory and it was finally abandoned. The original intention was to include under this heading those species, less than a metre high, with woody stems and unprotected buds, which are classified as chamaephytes under Raunkiaer's system. It was eventually found impossible, with the material and data available, to separate them satisfactorily from the "die-back" chamaephytes of category 9.

Two tables are given here. The first gives the numbers of species of the Balkan Peninsular flora for each family falling under the different heads of the simpler classification and also of Raunkiaer's scheme. The second in a similar way summarizes the results on the basis of the special scheme.

	Trees	*Shrubs*	*Perennial herbs*	*Biennials*	*Annuals*	*Raunkiaer's Life-forms*							
						MM	M	N	Ch	H	G	HH	Th
Taxaceae	1	..	..	..	..	1	1	..	..	..	..	..	..
Pinaceae	15	8	..	..	..	11	10	3	..	..	..	..	..
Gnetaceae	..	3	..	..	..	..	..	3	..	..	..	..	..
Typhaceae	..	..	6	..	..	..	..	..	..	..	..	6	..
Sparganiaceae	..	..	5	..	..	..	..	..	..	..	..	5	..
Potamogetonaceae	..	..	27	..	..	..	..	..	..	..	..	27	..
Naiadaceae	..	..	..	..	2	..	..	..	..	..	..	2	2
Scheuchzeriaceae	..	..	4	..	..	..	..	..	..	2	2	..	..
Alismataceae	..	..	6	..	..	..	..	..	..	..	..	6	..
Butomaceae	..	..	1	..	..	..	..	..	..	..	..	1	..
Hydrocharitaceae	..	..	3	..	..	..	..	..	..	..	..	3	..
Gramineae	..	..	221	13	140	..	..	..	3	196	34	14	140
Cyperaceae	..	..	127	..	13	..	..	..	..	96	18	35	13
Araceae	..	..	12	..	..	..	..	..	..	1	10	2	..
Lemnaceae	..	..	5	..	..	..	..	..	..	..	..	5	..
Juncaceae	..	..	35	..	5	..	..	..	..	23	12	2	5
Liliaceae	..	2	245	..	1	..	2	3	..	9	235	..	1
Amaryllidaceae	..	..	23	..	..	..	..	..	..	..	23	..	..
Dioscoreaceae	..	..	2	..	..	..	..	..	..	..	2	..	..
Iridaceae	..	..	61	..	..	..	..	..	..	17	43	1	..
Orchidaceae	..	..	97	..	..	..	..	..	..	4	93	..	..
Salicaceae	5	22	..	..	..	5	13	13	..	..	..	..	..
Juglandaceae	1	..	..	..	..	1	..	..	..	..	..	..	..
Betulaceae	10	6	..	..	..	8	7	1	..	..	..	..	..
Fagaceae	19	8	..	..	..	17	10	2	..	..	..	..	..
Ulmaceae	6	2	..	..	..	5	2	1	..	..	..	..	..
Moraceae	1	1	1	..	..	..	1	..	..	1	..	..	..
Urticaceae	..	..	5	..	3	..	..	..	..	5	..	..	3
Loranthaceae	..	3	..	..	..	..	..	3	..	..	..	..	..
Santalaceae	..	3	13	..	3	..	..	2	2	12	..	..	3
Aristolochiaceae	..	..	12	..	..	..	..	..	..	2	10	..	..
Rafflesiaceae	..	..	1	..	..	..	..	..	..	..	1	..	..
Polygonaceae	..	1	31	5	20	..	..	1	6	25	6	4	20
Chenopodiaceae	..	6	12	..	45	..	..	3	4	11	..	..	45
Amarantaceae	..	..	1	..	6	..	..	..	1	..	..	..	6
Cynocrambaceae	..	..	..	..	1	..	..	..	..	..	..	..	1
Phytolaccaceae	..	..	1	..	..	..	..	..	..	1	..	..	..
Aizoaceae	..	..	..	..	5	..	..	..	..	..	..	..	5
Portulacaceae	..	..	..	..	2	..	..	..	..	..	..	..	2
Caryophyllaceae	..	..	299	16	120	..	..	..	190	166	..	..	120
Nymphaeaceae	..	..	4	..	..	..	..	..	..	..	..	4	..
Ceratophyllaceae	..	..	3	..	..	..	..	..	..	..	..	3	..
Ranunculaceae	..	7	145	1	44	..	6	..	1	122	17	15	44
Berberidaceae	..	2	4	..	..	..	..	2	..	..	4	..	..
Lauraceae	1	1	..	..	..	1	1	..	..	..	..	..	..

	Trees	*Shrubs*	*Perennial herbs*	*Biennials*	*Annuals*	*Raunkiaer's Life-forms*							
						MM	M	N	Ch	H	G	HH	Th
Papaveraceae	..	..	16	1	38	..	..	..	..	7	9	..	38
Cruciferae	..	..	189	58	117	..	..	..	65	172	7	7	117
Capparidaceae	..	2	..	..	1	..	..	2	..	..	..	..	1
Resedaceae	..	..	3	3	4	..	..	..	1	5	..	..	4
Droseraceae	..	..	3	..	..	..	..	..	..	2	..	1	..
Crassulaceae	..	..	43	1	16	..	..	..	33	11	..	..	16
Saxifragaceae	..	5	34	2	4	..	..	5	25	15	..	..	4
Platanaceae	1	1	..	..	..	1	1	..	..	..	..	..	..
Rosaceae	23	91	84	..	1	6	43	54	2	100	..	..	1
Leguminosae	2	102	206	15	228	..	8	54	74	208	4	..	228
Geraniaceae	..	..	23	4	20	..	..	..	..	25	2	..	20
Oxalidaceae	..	..	3	..	..	..	..	..	..	3	..	..	..
Linaceae	..	2	28	1	9	..	..	2	20	16	..	..	9
Zygophyllaceae	..	..	3	..	2	..	..	..	2	1	..	..	2
Rutaceae	..	..	14	..	..	..	..	..	12	7	..	..	..
Polygalaceae	..	..	15	..	1	..	..	..	14	12	..	..	1
Euphorbiaceae	..	2	50	..	21	..	..	..	41	21	4	..	21
Callitrichaceae	..	..	7	..	..	..	..	..	..	..	..	7	..
Buxaceae	..	1	..	..	..	1	..	..	..	..	..	..	..
Empetraceae	..	1	..	..	..	..	..	..	1	..	..	..	..
Coriariaceae	..	1	..	..	..	..	1	..	..	..	..	..	..
Anacardiaceae	1	5	..	..	..	1	5	..	..	..	..	..	..
Aquifoliaceae	1	1	..	..	..	..	1	..	..	..	..	..	..
Celastraceae	..	4	..	..	..	..	4	2	..	..	..	..	..
Staphyleaceae	..	1	..	..	..	..	1	..	..	..	..	..	..
Aceraceae	9	5	..	..	..	8	6	..	..	..	..	..	..
Hippocastanaceae	1	..	..	..	..	1	..	..	..	..	..	..	..
Balsaminaceae	..	..	..	..	1	..	..	..	..	..	..	..	1
Rhamnaceae	..	20	..	..	..	..	6	20	..	..	..	..	..
Vitaceae	..	1	..	..	..	..	1	1	..	..	..	..	..
Tiliaceae	4	..	..	..	..	4	..	..	..	..	..	..	..
Malvaceae	..	..	15	4	12	..	..	..	3	19	..	..	12
Hypericaceae	..	..	52	..	..	..	..	..	35	31	..	..	..
Elatinaceae	..	..	..	..	5	..	..	..	..	..	..	5	5
Frankeniaceae	..	..	1	..	1	..	..	..	1	..	..	..	1
Tamaricaceae	..	8	..	..	..	..	7	8	..	..	..	..	..
Cistaceae	..	4	19	..	6	..	..	4	18	1	..	..	6
Violaceae	..	..	50	..	8	..	..	..	16	36	..	..	8
Datiscaceae	..	..	1	..	..	..	..	..	..	1	..	..	..
Thymelaeaceae	..	14	..	..	2	..	..	14	..	..	..	..	2
Elaeagnaceae	1	2	..	..	..	..	2	1	..	..	..	..	..
Lythraceae	..	..	3	..	8	..	..	..	..	3	..	..	8
Punicaceae	1	..	..	..	..	..	1	..	..	..	..	..	..
Myrtaceae	1	1	..	..	..	..	1	..	..	..	..	..	..

	Trees	*Shrubs*	*Perennial herbs*	*Biennials*	*Annuals*	*Raunkiaer's Life-forms*							
						MM	M	N	Ch	H	G	HH	Th
Oenotheraceae	..	..	22	..	..	..	..	..	2	17	3	2	..
Hippuridaceae	..	..	3	..	..	..	..	..	..	..	..	3	..
Cynomoriaceae	..	..	1	..	..	..	..	..	..	..	1	..	..
Araliaceae	..	2	..	..	..	1	2	..	..	..	..	..	..
Umbelliferae	..	1	233	35	68	..	..	1	2	233	18	14	68
Cornaceae	..	3	..	..	..	..	2	2	..	..	..	..	..
Pirolaceae	..	..	7	..	..	..	..	..	2	4	1	..	..
Ericaceae	2	19	..	..	..	2	3	13	5	..	..	..	..
Primulaceae	..	..	43	..	9	..	..	..	7	25	11	2	9
Plumbaginaceae	..	1	37	..	1	..	..	..	3	36	..	..	1
Ebenaceae	1	..	..	..	..	1	..	..	..	..	..	..	..
Styracaceae	1	1	..	..	..	..	1	..	..	..	..	..	..
Oleaceae	6	13	..	..	..	5	11	7	..	..	..	..	..
Gentianaceae	..	..	19	5	20	..	..	..	1	20	1	2	20
Apocynaceae	..	2	5	..	..	..	..	2	5	1	..	..	..
Asclepiadaceae	..	3	11	..	..	..	2	2	..	10	..	..	..
Convolvulaceae	..	1	20	..	13	..	..	..	10	11	..	..	13
Polemoniaceae	..	..	1	..	..	..	..	..	..	1	..	..	..
Borraginaceae	..	2	83	32	46	..	..	..	15	93	4	2	46
Verbenaceae	..	1	3	..	1	..	1	1	1	2	..	..	1
Labiatae	..	19	319	1	35	..	..	10	204	151	1	4	35
Solanaceae	..	4	9	2	6	..	..	4	3	8	1	..	6
Scrophulariaceae	..	1	110	89	111	..	..	..	40	157	4	5	111
Orobanchaceae	..	..	37	..	4	..	..	..	..	..	37	..	4
Gesneriaceae	..	..	5	..	..	..	..	..	..	5	..	..	..
Lentibulariaceae	..	..	10	..	..	..	..	..	..	5	..	5	..
Globulariaceae	..	1	6	..	..	..	..	1	3	6	..	..	..
Acanthaceae	..	..	4	..	..	..	..	..	..	4	..	..	..
Plantaginaceae	..	..	17	1	10	..	..	..	1	16	..	1	10
Rubiaceae	..	..	103	1	26	..	..	..	84	26	2	..	26
Caprifoliaceae	..	16	1	..	..	..	9	7	..	1	..	..	..
Adoxaceae	..	..	1	..	..	..	..	..	..	1	..	..	..
Valerianaceae	..	..	17	..	20	..	..	..	..	17	2	..	20
Dipsacaceae	..	..	57	10	21	..	..	..	12	51	2	..	21
Cucurbitaceae	..	..	6	..	..	..	..	..	..	6	..	..	..
Campanulaceae	..	..	107	27	14	..	..	..	21	109	5	..	14
Compositae	..	4	610	154	166	..	..	4	72	700	7	..	166
TOTALS	114	443	4181	481	1486	80	172	258	1063	3105	636	195	1486

	1. *Evergreen trees*	2. *Deciduous trees*	3. *Evergreen shrubs*	4. *Deciduous shrubs*	5. *Woody lianes*	6. *Switch plants*	7. *Spiny plants*	8. —	9. *Die-back chamaephytes*	10. *Grass-like plants*	11. *Rush and sedge plants*	12. *Typical chamaephytes*	13. *Cushion plants*	14. *Rosette plants*	15. *Climbing herbs*	16. *Die-back hemicryptophytes*	17. *Geophytes*	18. *Therophytes*	19. *Hydrophytes*	20. *Parasites or saprophytes*
Taxaceae	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Pinaceae	15	..	8	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Gnetaceae	..	..	3	..	..	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Typhaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6	..	..	..	..
Sparganiaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	..	..	..	..
Potamogetonaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	27	..
Naiadaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	2	..
Scheuchzeriaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	2	..	..	..
Alismataceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	1	..	..	..
Butomaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..
Hydrocharitaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3	..	..	..	..
Gramineae	..	..	..	..	..	..	..	..	..	358	..	..	..	..	..	..	..	140	..	..
Cyperaceae	..	..	..	..	..	..	..	..	..	122	19	..	..	..	..	..	..	13	..	..
Araceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	11	..	..	..
Lemnaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	..
Juncaceae	..	..	..	..	..	..	..	..	..	18	20	..	..	..	..	..	..	5	..	..
Liliaceae	..	..	3	..	2	..	6	..	..	..	..	..	..	..	..	9	235	1	..	..
Amaryllidaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	23	..	..	..
Dioscoreaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	2	..	..	..
Iridaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	18	43	..	..	..
Orchidaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	91	..	..	2
Salicaceae	..	5	..	22	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Juglandaceae	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Betulaceae	..	10	..	6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Fagaceae	2	17	2	6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Ulmaceae	..	6	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Moraceae	..	1	..	1	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..
Urticaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	..	3	..	..
Loranthaceae	..	..	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3
Santalaceae	..	..	1	..	..	..	..	..	2	..	..	2	..	..	..	11	..	3	..	17
Aristolochiaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	2	10	..	..	..
Rafflesiaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	1
Polygonaceae	..	..	..	..	..	..	1	..	..	..	..	6	..	..	..	26	6	20	2	..
Chenopodiaceae	..	..	..	..	..	..	..	..	13	..	..	..	..	..	..	3	..	45	..	..
Amarantaceae	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	6	..	..
Cynocrambaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..
Phytolaccaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..
Aizoaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	..	..

	1. *Evergreen trees*	2. *Deciduous trees*	3. *Evergreen shrubs*	4. *Deciduous shrubs*	5. *Woody lianes*	6. *Scrub plants*	7. *Spiny plants*	8.—	9. *Die-back chamaephytes*	10. *Grass-like plants*	11. *Rush and sedge plants*	12. *Typical chamaephytes*	13. *Cushion plants*	14. *Rosette plants*	15. *Climbing herbs*	16. *Die-back hemicryptophytes*	17. *Geophytes*	18. *Therophytes*	19. *Hydrophytes*	20. *Parasites or saprophytes*
Portulacaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..
Caryophyllaceae	..	..	..	..	..	..	..	..	105	..	..	170	6	..	..	113	..	120	..	..
Nymphaeaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	..
Ceratophyllaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3	..
Ranunculaceae	..	..	..	..	..	7	..	..	..	..	..	..	..	..	..	123	17	44	8	..
Berberidaceae	..	..	..	2	..	..	..	..	..	..	..	..	..	..	..	..	4	..	..	..
Lauraceae	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Papaveraceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	8	9	38	..	..
Cruciferae	..	..	..	..	..	..	..	..	48	..	..	31	..	5	..	167	7	117	..	..
Capparidaceae	..	..	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..
Resedaceae	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	5	..	4	..	..
Droseraceae	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..	..	1	..
Crassulaceae	..	..	..	..	..	..	..	..	5	..	..	33	..	3	..	11	..	16	..	..
Saxifragaceae	..	..	..	5	..	..	1	..	6	..	..	21	7	..	..	15	..	4	..	..
Platanaceae	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Rosaceae	..	22	3	41	49	..	66	..	2	..	..	..	..	..	..	80	..	1	..	..
Leguminosae	1	3	1	42	..	6	28	..	67	..	..	4	..	6	..	204	4	228	..	..
Geraniaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	24	2	20	..	..
Oxalidaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	1	..	..	..	..
Linaceae	..	..	..	2	..	..	..	..	9	..	..	13	..	..	..	16	..	9	..	..
Zygophyllaceae	..	..	..	..	..	..	1	..	2	..	..	..	..	..	..	1	..	2	..	..
Rutaceae	..	..	..	..	..	..	..	..	11	..	..	..	..	..	..	7	..	..	..	..
Polygalaceae	..	..	..	..	..	..	..	..	4	..	..	10	..	..	..	12	..	1	..	..
Euphorbiaceae	..	..	..	..	..	..	2	..	27	..	..	20	..	..	..	14	4	21	..	..
Callitrichaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	7	..
Buxaceae	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Empetraceae	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Coriariaceae	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Anacardiaceae	..	1	1	4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Aquifoliaceae	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Celastraceae	..	..	..	4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Staphyleaceae	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Aceraceae	..	9	..	5	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..
Hippocastanaceae	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Balsaminaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..
Rhamnaceae	..	..	..	20	..	..	12	..	..	..	..	..	..	..	..	..	..	..	..	..

	1. *Evergreen trees*	2. *Deciduous trees*	3. *Evergreen shrubs*	4. *Deciduous shrubs*	5. *Woody lianes*	6. *Switch plants*	7. *Spiny plants*	8. —	9. *Die-back chamaephytes*	10. *Grass-like plants*	11. *Rush and sedge plants*	12. *Typical chamaephytes*	13. *Cushion plants*	14. *Rosette plants*	15. *Climbing herbs*	16. *Die-back hemicryptophytes*	17. *Geophytes*	18. *Therophytes*	19. *Hydrophytes*	20. *Parasites or saprophytes*
Vitaceae	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Tiliaceae	..	4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Malvaceae	..	..	..	..	..	..	..	..	3	..	..	..	..	..	..	19	..	12	..	..
Hypericaceae	..	..	..	..	..	..	..	..	14	..	..	22	..	..	..	31	..	..	..	..
Elatinaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	..	..
Frankeniaceae	..	..	..	..	..	..	..	..	1	..	..	1	..	..	..	..	..	1	..	..
Tamaricaceae	..	..	8	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cistaceae	..	..	4	..	..	..	..	..	17	..	..	8	..	..	..	1	..	6	..	..
Violaceae	..	..	..	..	..	..	..	..	10	..	..	6	..	16	..	27	..	8	..	..
Datiscaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..
Thymelaeaceae	..	..	12	2	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..
Elaeagnaceae	..	1	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Lythraceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3	..	8	..	..
Punicaceae	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Myrtaceae	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Oenotheraceae	..	..	..	..	..	..	..	..	2	..	..	1	..	..	..	17	3	..	1	..
Hippuridaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3	..
Cynomoriaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	1
Araliaceae	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Umbelliferae	..	..	1	..	..	..	15	..	2	..	..	..	..	..	..	248	18	68	..	..
Cornaceae	..	..	..	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Pirolaceae	..	..	..	..	..	..	..	..	2	..	..	..	..	4	..	..	1	..	..	1
Ericaceae	2	..	13	5	..	..	..	..	3	..	..	..	..	..	..	..	..	..	..	..
Primulaceae	..	..	..	..	..	..	..	..	..	..	..	7	2	21	..	5	11	9	..	..
Plumbaginaceae	..	..	..	..	..	..	1	..	2	..	..	1	..	33	..	4	..	1	..	..
Ebenaceae	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Styracaceae	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Oleaceae	1	4	6	7	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..
Gentianaceae	..	..	..	..	..	..	..	..	..	..	..	1	..	8	..	17	1	20	2	..
Apocynaceae	..	..	..	..	..	..	..	..	3	..	..	4	..	..	..	1	..	..	..	..
Asclepiadaceae	..	..	..	1	2	..	..	..	1	..	..	..	..	..	..	10	..	..	..	..
Convolvulaceae	..	..	..	..	..	..	..	..	4	..	..	6	..	..	7	4	..	13	..	10
Polemoniaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..
Borraginaceae	..	..	2	..	..	..	..	..	15	..	..	..	..	..	..	95	4	46	..	..
Verbenaceae	..	..	..	1	..	..	..	..	1	..	..	1	..	..	..	2	..	1	..	..
Labiatae	..	..	8	6	..	..	6	..	122	..	..	97	..	..	..	152	1	35	..	..

	1. *Evergreen trees*	2. *Deciduous trees*	3. *Evergreen shrubs*	4. *Deciduous shrubs*	5. *Woody lianes*	6. *Switch plants*	7. *Spiny plants*	8. —	9. *Die-back chamaephytes*	10. *Grass-like plants*	11. *Rush and sedge plants*	12. *Typical chamaephytes*	13. *Cushion plants*	14. *Rosette plants*	15. *Climbing herbs*	16. *Die-back hemicryptophytes*	17. *Geophytes*	18. *Therophytes*	19. *Hydrophytes*	20. *Parasites or saprophytes*
Solanaceae	..	..	..	4	1	..	2	..	3	..	..	..	..	..	..	8	1	6	..	..
Scrophulariaceae	..	..	..	..	..	..	..	..	28	..	..	15	..	9	..	156	4	111	..	93
Orobanchaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	37	4	..	41
Gesneriaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	5	..	..	..	..	..	..
Lentibulariaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	5	..	..	..	..	5	
Globulariaceae	..	..	..	..	..	..	..	..	3	..	..	..	..	3	..	3	..	..	..	
Acanthaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	..	..	..	
Plantaginaceae	..	..	..	..	..	..	..	..	1	..	..	..	..	16	..	1	..	10	..	
Rubiaceae	..	..	..	..	..	..	..	..	62	..	..	25	3	..	..	26	2	26	..	
Caprifoliaceae	..	1	..	12	4	..	..	..	..	..	..	..	..	..	..	1	..	..	..	
Adoxaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	
Valerianaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	17	2	20	..	..
Dipsacaceae	..	..	..	..	..	..	1	..	11	..	..	1	..	..	..	51	2	21	..	..
Cucurbitaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6	..	..	..	..
Campanulaceae	..	..	..	..	..	..	..	..	7	..	..	15	..	..	..	108	5	14	..	..
Compositae	..	..	..	4	..	..	128	..	74	..	..	..	..	94	..	629	7	166	..	..
Totals	24	90	84	215	67	9	272	..	694	498	39	521	18	234	12	2554	571	1486	70	169

ANALYSES OF THE TABLES

Duration. On the basis of duration the perennial herbs form by far the commonest specific type and the actual number exceeds expectations. The number of annuals is not higher than was expected, for the dry summers of the Mediterranean domain favour early flowering and rapid setting of seed, both of which features are characteristic of most of the annuals. Moreover, annuals occur prevalently in open communities, which are especially common in the Mediterranean and transitional districts of the Balkan Peninsula. The shrub category is used with a wide denotation to include all woody plants below the size of and without the trunk development of trees.

Raunkiaer's classification and biological spectra. Reduced to a percentage basis (to the first place of decimals) the analysis of the flora of

the Balkan Peninsula on Raunkiaer's classification gives the following biological spectrum:

MM/1·1 M/2·4 N/3·7 Ch/15·2 H/44·4 G/9·1 HH/2·8 Th/21·2.

The flora as a whole is dominantly hemicryptophytic but the therophytes and chamaephytes are strongly represented. None of the biological spectra which I have seen published by various authors agree closely with ours, and the differences are instructive. Of the spectra given by Raunkiaer himself that for Denmark agrees most nearly with that for the Balkan Peninsula, especially for the hemicryptophytes (50) and therophytes (18), but the helophyte-hydrophyte number is higher (11), and the chamaephyte number lower (3). The normal spectrum given by Raunkiaer as based on calculations for all known flowering plants is:

S/1 E/3 MM/6 M/17 N/20 Ch/9 H/27 G/3 HH/1 Th/13.

Although some ecologists consider it to have little value for purposes of comparison, we may notice the following differences between this spectrum and that for the whole Balkan Peninsular flora. (i) In the latter the phanerophytic percentage is very much reduced. The region lies outside the climatic zone especially favourable to phanerophyte development, that is, outside the zone of tropical climate with abundant precipitation. (ii) The chamaephytic percentage is higher in the Balkan Peninsular flora, indicating again less favourable conditions for vegetation. (iii) The hemicryptophytes have a much higher percentage in our flora than in that of the world as a whole. It will be shown below that it is especially the Central European districts which account for this. (iv) The geophytic percentage is increased for the Balkan Peninsular flora relative to that of the world flora. A higher proportion of the Monocotyledons in our flora is definitely geophytic than in the tropics, whose vegetation dominates the normal spectrum. (v) The percentage of helophyte-hydrophytes is higher for the Balkan Peninsular flora, but even in this the figure is not a dominating one. (vi) The therophytic percentage is higher for our flora than in the estimate for the world flora. As is shown below the flora of the Mediterranean domain of the Balkan Peninsula accounts for this.

Some interesting facts emerge from a study of the numbers in the different categories for the individual families and larger groups. The following are largely or predominantly phanerophytic: *Gymnospermae*, *Salicaceae*, *Juglandaceae*, *Betulaceae*, *Fagaceae*, *Ulmaceae*, *Loranthaceae*, *Lauraceae*, *Capparidaceae*, *Rosaceae*, *Anacardiaceae*, *Aquifoliaceae*, *Celastraceae*, *Staphyleaceae*, *Aceraceae*, *Hippocastanaceae*, *Rhamnaceae*, *Vitaceae*, *Tiliaceae*, *Tamaricaceae*, *Thymelaeaceae*, *Elaeagnaceae*, *Punicaceae*, *Myrtaceae*, *Araliaceae*, *Cornaceae*, *Ericaceae*, *Styracaceae*,

Oleaceae, and *Caprifoliaceae*. The highest numbers of chamaephytes occur in: *Caryophyllaceae*, *Cruciferae*, *Crassulaceae*, *Saxifragaceae*, *Leguminosae*, *Linaceae*, *Euphorbiaceae*, *Hypericaceae*, *Cistaceae*, *Violaceae*, *Labiatae*, *Scrophulariaceae*, *Rubiaceae*, and *Compositae*. The majority of the hemicryptophytes are accounted for by the following families: *Gramineae*, *Cyperaceae*, *Juncaceae*, *Polygonaceae*, *Caryophyllaceae*, *Ranunculaceae*, *Cruciferae*, *Rosaceae*, *Leguminosae*, *Geraniaceae*, *Euphorbiaceae*, *Malvaceae*, *Hypericaceae*, *Violaceae*, *Umbelliferae*, *Primulaceae*, *Plumbaginaceae*, *Gentianaceae*, *Borraginaceae*, *Labiatae*, *Scrophulariaceae*, *Rubiaceae*, *Dipsacaceae*, *Campanulaceae*, and *Compositae*. The majority of the geophytes (472 out of 636) are Monocotyledons. Of dicotyledonous families the following contain most geophytes: *Aristolochiaceae*, *Ranunculaceae*, *Papaveraceae*, *Umbelliferae*, *Primulaceae*, and *Orobanchaceae*. Of the 181 helo-hydrophytes 109 are Monocotyledons, the *Potamogetonaceae* and *Cyperaceae* accounting for 62. Of the dicotyledonous families the following contribute most to this category: *Ranunculaceae*, *Cruciferae*, *Callitrichaceae*, *Elatinaceae*, *Umbelliferae*, *Scrophulariaceae*, and *Lentibulariaceae*. Excluding the 140 annual grasses, the Monocotyledons of our flora contain only 21 therophytes. The principal contributions of dicotyledonous families to the therophytic total are made by the families *Polygonaceae*, *Chenopodiaceae*, *Caryophyllaceae*, *Ranunculaceae*, *Papaveraceae*, *Cruciferae*, *Leguminosae*, *Geraniaceae*, *Euphorbiaceae*, *Umbelliferae*, *Gentianaceae*, *Borraginaceae*, *Labiatae*, *Scrophulariaceae*, *Rubiaceae*, *Valerianaceae*, *Dipsacaceae*, and *Compositae*. No family contributes to every category, though if the phanerophytes be counted as one category the following families just do so: *Polygonaceae*, *Ranunculaceae*, *Umbelliferae*, and *Labiatae*, while *Leguminosae* and *Compositae* lack only helophytes and hydrophytes. Most of the families have a distinct bias towards one or two categories. Thus the *Pinaceae*, *Rhamnaceae*, and a number of smaller families are all phanerophytes, the *Liliaceae*, *Iridaceae*, and *Orchidaceae* are mainly geophytes, the *Gramineae*, *Ranunculaceae*, *Cruciferae Leguminosae*, *Geraniaceae*, *Malvaceae*, *Gentianaceae*, *Borraginaceae*, *Scrophulariaceae*, *Plantaginaceae*, and *Dipsacaceae* are mostly hemicryptophytes or therophytes, the *Labiatae* and *Caryophyllaceae* are predominantly chamaephytes and hemicryptophytes, while the *Umbelliferae* and *Compositae* are mainly hemicryptophytes.

Since the above tables deal with the whole flora of the Balkan Peninsula, an area where the Mediterranean and Central European climatic zones merge, the biological spectra for two widely separated districts, Crete and Serbia, have been calculated. Crete is entirely in the Mediterranean domain, though it must be remembered that its mountains rise to a considerable altitude. Serbia is in the Central European

domain though Mediterranean influences are not entirely absent. On a percentage basis, to the first decimal place, the following are the spectra obtained:

Crete: MM/1·3 M/2·9 N/4·8 Ch/13·3 H/27·1 G/10·2 HH/2·0 Th/38·3
Serbia: MM/1·7 M/2·8 N/3·4 Ch/11·3 H/46·2 G/9·1 HH/4·7 Th/20·7

The total numbers of species falling into the different categories are:

Crete: MM/21 M/46 N/76 Ch/209 H/426 G/160 HH/32 Th/601
Serbia: MM/47 M/78 N/92 Ch/310 H/1,264 G/248 HH/128 Th/567

The following comparisons and contrasts must be noticed between the spectra and the total numbers for the flora of the two districts. (1) The phanerophytic percentages are fairly close, although owing to the total number of species being greater in the Serbian than in the Cretan flora, the former has actually more phanerophytes than the latter. (2) The chamaephytic percentage is slightly higher for the Cretan flora. (3) The hemicryptophytic percentage dominates in the Serbian spectrum, but in the Cretan is lower than the therophytic percentage. For Serbia the hemicryptophytes approach to half the total number of species, for Crete they are only just over a quarter. (4) The geophytic percentages are fairly close, that for Crete being slightly higher. (5) The helophytes and hydrophytes are higher for Serbia than for Crete. The aquatic and marsh flora of Crete is remarkably poor. (6) The therophytic percentage dominates in the Cretan spectrum but is subordinate to that for hemicryptophytes in the Serbian. The very obvious conclusion is that Crete, a district of the Mediterranean domain, has a therophytic climate, and Serbia, a district of the Central European domain, has a hemicryptophytic climate. The winter-rain and summer-drought conditions of the Mediterranean climate favour spring and early summer flowering annuals, which rapidly set their seed while moisture is sufficient and when the increasing warmth favours germination and growth. Moreover, on the whole, the vegetation of the Mediterranean domain is naturally more open than that of the Central European domain, thus more space is available for temporary colonization. The winter warmth is greater in the Mediterranean districts than in the Central European and this would give seeds a better chance of successful hibernation, a fact of greater importance for annuals than for perennials, since the former depend for their propagation entirely on the seeds which germinate each year, and the entire failure of the seeds in any single year would exterminate the species. For the most part, however, the annual habit is correlated with summer drought not with winter cold. The aerial parts of the therophytes, and of the geophytes, are usually mesomorphic, i.e. structurally suited for life in air and soil which are neither excessively dry

nor excessively moist, since their functions are completed before the summer drought becomes the dominating factor in the life of the vegetation. Hence, apart from the evergreen communities, the vegetation of the Mediterranean domain in spring and early summer has a mesophytic aspect contrasting markedly with the xerophytic aspect in the height of summer. In the Central European districts, on the other hand, the general mesophytic aspect lasts throughout the summer.

A comparison may now be made between the spectrum for Crete and the spectra worked out by Raunkiaer for many areas, but not for any district of the Balkan Peninsula as here understood. The closest agreement is with the spectrum for Samos.

Samos: MM/1 M/4 N/4 Ch/13 H/32 G/11 HH/2 Th/33
Crete: (whole numbers) MM/1 M/4 N/5 Ch/13 H/27 G/10 HH/2 Th/38.

It will be seen that the degree of coincidence is remarkable, since the spectra were obtained by absolutely independent calculations and were based upon very different species numbers. Samos, a much smaller island than Crete, is situated a little more than two degrees to the north in the Aegean, and close to the western coast of Asia Minor. It is, perhaps, placing undue reliance on the complete accuracy of the figures to suggest that the more northern position of Samos accounts for the somewhat higher percentage of hemicryptophytes and the lower percentage of therophytes in its spectrum than in that of Crete. However, a further comparison with the spectra for Tripoli and Cyrenaica suggests that even these detailed differences in the figures express facts of importance. The spectra for Tripoli and Cyrenaica are given by Raunkiaer as:

Tripoli: N/6 Ch/13 H/19 G/9 HH/2 Th/51
Cyrenaica: MM/1 M/1 N/7 Ch/14 H/19 G/8 HH/– Th/50.

These two areas are approximately as far to the south of Crete as Samos is to the north. The spectra relative to that of Crete show the reverse differences, and these in a greater degree, from those between the spectra for Crete and Samos. There is a decrease in the hemicryptophytic percentage and a considerable increase in the therophytic percentages, indicating very clearly a type of climate approximating more closely to desert. The actual floristic connexion between Crete and the Balkan Peninsula, the Aegean islands, and Asia Minor is shown in Chapter XV to be closer than between Crete and North Africa, and this connexion is also emphasized by a study of the vegetation based on life-forms.

The spectrum for the Serbian flora agrees most closely with that for Denmark as given by Raunkiaer:

Denmark: MM/1 M/3 N/3 Ch/3 H/50 G/11 HH/11 Th/18
Serbia: (whole numbers) MM/2 M/3 N/3 Ch/11 H/46 G/9 HH/5 Th/21.

The Serbian flora has a greater proportion of chamaephytes and a smaller proportion of helophytes and hydrophytes than the Danish. The figure for the latter in Denmark is exceptionally high, and is not exceeded in any of the spectra given by Raunkiaer, and only equalled in that for South Labrador! The more southern position of Serbia and the fact that Mediterranean species penetrate into its flora account for the higher percentage of chamaephytes. The published spectra indicate a correlated percentage increase of therophytes and chamaephytes and a decrease of hemicryptophytes from north to south in the Nearer East.

Extended scheme. The results obtained by an analysis of the vegetation of the Balkan Peninsula obtained on the basis of the extended scheme described on p. 78 must now be considered.

1. *Evergreen trees.* The evergreen tree[1] habit is confined to (*a*) species essentially belonging to the Mediterranean domain, and (*b*) Gymnosperms of the Central European domain. 16 species of Gymnosperms are placed in this category, and, as detailed in the family tables, these are partly Mediterranean and partly Central European in their distribution. The Angiosperms are *Quercus coccifera* L., *Q. ilex* L., *Laurus nobilis* L., *Ceratonia siliqua* L., *Myrtus communis* L., *Arbutus unedo* L., *A. andrachne* L., and *Olea europaea* L. Most of these also occur as sclerophyllous shrubs in the macchie or pseudo-macchie. A partial evergreen condition is shown by some species, of which *Quercus macedonica* Griseb. may attain the tree habit. An evergreen variety of *Platanus orientalis* L. is known from Crete.

2. *Deciduous leaved trees.* These are nearly four times as numerous as the evergreen trees, and are distributed in both Mediterranean and Central European domains. All are Dicotyledons, and many merge into the category of deciduous leaved shrubs. The earlier families of the *Archichlamydeae* in Engler's system account for 40 species of the total 90, 10 of these belonging to the *Betulaceae*, and 17 to the *Fagaceae*. Twenty-two species are placed in the *Rosaceae*, most in the

[1] The best definition of a tree which I have found is that given by B. E. Fernow in *Garden and Forest*, ii. 410 (1888) as follows: 'Trees are woody plants, the seed of which has the inherent capacity of producing naturally, within their native limits, one main erect axis bearing a definite crown, continuing to grow for a number of years more vigorously than the lateral axes, and the lower branches dying off in time.' This definition would be improved by the omission of the last eight words.

genera *Prunus* and *Pyrus*, accepted here in a broad sense. The *Aceraceae* account for 9 species, *Tiliaceae* and *Oleaceae* for 4 each, and *Leguminosae* for 3, the rest being scattered as single species amongst various families. Only 7 species are counted amongst the *Metachlamydeae*. Nearly all of the species are early flowering, most setting their fruit by the end of April. While the numbers of individuals have been and are being very much reduced no definite evidence has been obtained that the Balkan Peninsular distribution as estimated in this work for individual species has been restricted by man's activities.

3. *Evergreen shrubs*. Plants in this category are relatively well represented in our flora by 84 species. A considerable number of these are restricted to the Mediterranean domain, occurring especially in the macchie. The principal families into which the species are classified are: *Pinaceae* (8 spp.), *Tamaricaceae* (8 spp.), *Thymelaeaceae* (12 spp.), *Ericaceae* (13 spp.), *Oleaceae* (6 spp.), and *Labiatae* (8 spp.). With the exception of 11 *Gymnospermae* and 3 *Liliaceae* (*Ruscus* spp.) all are Dicotyledons. Gradations between this group and that of evergreen trees occur in the *Coniferae*, *Fagaceae*, *Lauraceae*, *Leguminosae*, *Myrtaceae*, and *Oleaceae*. It has sometimes been difficult also to separate plants of this category from those of category 9, the 'die-back chamaephytes'. A number of species such as *Quercus macedonica* Griseb. *Forsythia europaea* Deg. et Bald., and *Ligustrum vulgare* L. may retain their leaves through the winter, shedding them just before or just after the new buds open in the spring. Such species have not been counted as true evergreens, since they vary in this respect according to the habitat and the severity of the winter season.

4. *Deciduous leaved shrubs*. The species in this category total 215, a higher total than for the species of the three previous categories together. They are all Dicotyledons, and the chief families contributing are: *Salicaceae* (22 spp.), *Betulaceae* (6 spp.), *Rosaceae* (41 spp.), *Leguminosae* (42 spp.), *Rhamnaceae* (20 spp.), *Oleaceae* (7 spp.), *Labiatae* (6 spp.), and *Caprifoliaceae* (12 spp.). This life-form is found abundantly in both the Mediterranean and Central European domains, but the brushwood associations which it dominates are more characteristic of the latter than of the former. There are naturally gradations to the category of deciduous leaved trees and to that of the 'die-back chamaephytes'. Relative to the former the shrubs show decrease in height combined with relative increase of branching, without the formation of a distinct bole. Naturally shrubs form forest undergrowth and communities marginal to forest or intermediate between this and other formations, such as grassland, or they may form climatic climax associations. The latter are probably represented by some of the shiblyak of the north-eastern parts of the Balkan Peninsula, but the

great areas of deciduous brushwood found in nearly all the districts must be regarded as secondary and due to human interference with normal climax vegetation. The mesophytic shiblyak largely represents a stage in the development towards deciduous forest, a new succession having been initiated by forest destruction. In the relatively few instances where this succession is allowed to proceed the light-demanding shrubby species are eventually killed by the trees growing up and shading them. An instance of this I examined near Sičevo in eastern Serbia in 1922, where shiblyak was passing into deciduous oak forest dominated by *Quercus lanuginosa* Thuill. and *Q. conferta* Kit. Such shrubs as *Syringa vulgaris* L. and *Cornus mas* L. were disappearing as the tree growth increased and were absent from the forest climax dominated by high trees. The species dominant as undergrowth in woods in the Balkan Peninsula are usually different from those dominant in brushwood.

5. *Woody lianes and sprawlers.* Plants of this habit total 67 species, chiefly contributed by the following families: *Ranunculaceae* (7 spp.), *Rosaceae* (49 spp.), and *Caprifoliaceae* (4 spp.). Except for two species of *Smilax* all are Dicotyledons. Of the liane type the following are representatives: *Smilax aspera* L., *S. excelsa* L., *Clematis* spp., *Vitex vinifera* L., *Cynanchum acutum* L., *Periploca graeca* L., and *Lonicera* spp. Most of the *Rosaceae* placed in this category are species of *Rubus* and *Rosa* and are woody sprawlers.

6. *Switch plants (leafless, or nearly leafless).* These total only 9 species, 3 *Gnetaceae*, and 6 *Leguminosae*. The habit certainly reduces transpiration and it may be noted that nearly all the species in this category grow in dry, stony or rocky places. There are a number of *Leguminosae*, especially some species of *Genista*, and also species of other families (*Osyris alba* L., *Polygonum equisetiforme* S. et S.), which resemble the switch plants in that much of the work of assimilation is carried on by the green stems. As in most life-forms there is no absolutely sharp line of demarcation from other categories. A very typical switch plant is *Spartium junceum* L., which has a wide distribution in the Mediterranean and transitional domains of the Balkan Peninsula. It is very characteristic of the macchia but is not limited to this community.

7. *Plants with spines, thorns, or strong prickles.* This category is quite an artificial one and its members have been included in other categories according to their habit and life-form. The species included here number 272, and are a heterogeneous assemblage except that all have spines or strong prickles showing lignification. There are all grades between hairs and strong prickles, and it has not always been easy to decide whether a given species should or should not be included in this category. All species with woody spines representing metamor-

phosed stem branches or leaves or leaf-parts have been included, such as *Crataegus* spp. with stem spines, *Berberis* spp. with leaf spines, and *Paliurus spina-Christi* Mill. with stipular spines. From the standpoint of protection and also from that of the causal influence of drought one is justified in including also those plants, such as some of the thistles, *Xanthium spinosum* L., *Acanthus spinosissimus* Pers., and *Morina persica* L., which have very strong prickles into which the leaf-veins pass, or which are otherwise lignified. The *Compositae* are especially represented amongst the last. The spiny habit is partially correlated with the lack of abundant moisture, though dwarfing also encourages it, even when this is due to other causes than drought, e.g. the eating back of the young shoots by browsing animals, as in *Acer orientale* L. The absence of spiny and prickly plants in aquatic and marsh habitats is normal for most parts of the world, and the converse of increasing drought leading to increasing spinosity in the vegetation is also generally true. Two groups of facts must, however, be distinguished, firstly that under drought conditions species and individuals become more spiny or prickly than under mesophytic conditions, and secondly that the dry environment has a selective influence favouring those species with xeromorphic structure, and since spine or prickle formation is frequently correlated with reduced leaf-surface or sclerophylly, it follows that plants having such will frequently have a greater chance of survival than those without. *Quercus coccifera* L. when growing as a dwarf shrub of the pseudo-macchie is usually, at least on dry hill-slopes in South Macedonia, a dense prickly mass. The sheep and goats, by eating the young shoots, are a biological factor in preventing the bushes reaching to tree size. I have, however, seen small trees of this species growing under protected conditions in the same district, the leaf-margins having very reduced prickles and being much more entire than in the shrub form. The potentiality of prickle production is strong in the species, but is best expressed under conditions of drought and dwarfing. *Q. ilex* L. also shows variation in the leaf-margin, but the prickles are usually much less developed than in *Q. coccifera*, or are entirely absent. In other words, as a shrub of the Greek and Cretan floras it has a less marked potentiality for spine production under the same conditions of drought and biologic dwarfing than the kermes oak. *Acer orientale* L. is frequently developed as a compact thorny bush from the centre of which one or more flower-bearing shoots arise, but it also occurs as a large shrub with no spines. The selective influence of drought is well illustrated by the predominance of prickly herbaceous plants which reach their maximum development and flower in the summer in the Mediterranean domain. It has been emphasized in the chapter on climate that while no district of the Balkan Peninsula

can be said to have a low total annual rainfall, there is in the Mediterranean districts a marked periodity in the precipitation, the dry season coinciding with the hot season. In many such districts the spring and early summer vegetation has a luxuriant mesophytic appearance, and that of midsummer a xerophytic appearance and floristic composition. The summer flora, in other words, tends towards a semi-desert type. A very characteristic feature of the summer flora is the abundance of thistles and thistle-like plants. These are herbaceous, but include perennials, biennials, and annuals. From the middle of June to September such plants flourish in dry stony ground. The flocks of sheep and goats are mostly in the mountains at this time, and it is doubtful if the prickles have much selective value on the score of protection from herbivorous animals. The exposure of dry slopes by the destruction of woody associations and the common practice of leaving arable land fallow for several years certainly favour their spread. Spiny and prickly species are more numerous, and their individuals are more frequently dominants in characteristic associations, as in the phrygana, in the Mediterranean than in the Central European domain.

The taxonomic distribution of plants of this category yields some facts of interest. The *Liliaceae*, contributing 6 species, are the only monocotyledonous family represented. The *Rosaceae* contribute 66 species, a majority being species of *Rosa* and *Rubus* with stem prickles, and the *Leguminosae* 28. In the latter family the genus *Astragalus*, with species mostly of Oriental affinities, contains the section *Tragacantha* DC. where the persistent petioles and leaf-rhachides form spines which are often strong and lignified. 12 species of *Rhamnaceae* have stem or leaf spines, and 15 of *Umbelliferae* have leaf prickles. The latter are partly species of *Eryngium*. The 128 species of *Compositae* in this category are plants with stem and leaf prickles.

9. *Perennial herbs or sub-shrubs, partially woody at the base and with the aerial parts dying back for the unfavourable season but not right to ground level.* This is the category of the 'die-back' chamaephytes, and includes 694 species. Transitions occur especially to the more typical chamaephytes of category 12 and to the hemicryptophytes of category 16. By modifying the conditions of cultivation between a cold frame and the open ground during the winter at Kew I have been able to cause individuals of the same species (in the genera *Veronica*, *Dianthus*, *Potentilla*, and *Salvia*) to behave either as die-back chamaephytes or as hemicryptophytes. It is a reasonable assumption that such a variation would occur in nature according to local habitat and seasonal conditions. The dying back may be associated with summer drought, as in some *Cruciferae*, or with winter cold, as in many *Caryophyllaceae*, especially the high mountain species. There is also a tendency for

some shrubs to approach this life-form, in that their young shoots may die off under abnormally severe conditions. This is the more likely to happen at the extremity of their ranges in latitude or in altitude, and I have observed it especially with Balkan Peninsular species of *Cytisus* and allied genera in cultivation at Kew. The flowers are borne on the new elongations developed by the lower shoots, or from buds on these. The life-form is really transitional between shrubs or typical chamaephytes and hemicryptophytes.

None of the Monocotyledons comes into this category. Of the dicotyledonous families the following contribute 10 or more species: *Chenopodiaceae* (13), *Caryophyllaceae* (105), *Cruciferae* (48), *Leguminosae* (67), *Rutaceae* (11), *Euphorbiaceae* (27), *Hypericaceae* (14), *Cistaceae* (17), *Violaceae* (10), *Borraginaceae* (15), *Labiatae* (122), *Scrophulariaceae* (28), *Rubiaceae* (62), *Dipsacaceae* (11), and *Compositae* (74).

10. *Grasses and grass-like plants.* All the species in this category are Monocotyledons. *Acorus calamus* L. has been included here, with some hesitation, but apart from this the 499 species are composed of 358 *Gramineae*, 122 *Cyperaceae*, and 18 *Juncaceae*. The category is a natural one in what it includes, but there are many other Monocotyledons which might be included, as species of *Typha*, *Sparganium*, and even many of the geophytes with narrow linear or linear-lanceolate leaves. It is sufficient to show that though the climate of large parts of the Balkan Peninsula is not a good grassland climate, because of the unequal seasonal distribution of the rainfall in the Mediterranean and transitional domains, yet the number of grasses and grass-like species is fairly high. In other words, the number of species in a category does not necessarily coincide with the degree of development of the community or communities which they characterize.

11. *Rush and sedge forms with obsolete or nearly obsolete leaves.* This category is the herbaceous equivalent of that containing the switch plants. All of the representatives are Monocotyledons consisting of 19 *Cyperaceae* and 20 *Juncaceae*. Most of them are marsh and bog plants, and the ecological significance of the habit has never been adequately explained.

12. *Perennial herbs and sub-shrubs with perennial aerial runners or sprawling herbaceous stems.* This category includes the typical chamaephytes. A considerable number of them are high mountain plants protected during the winter by a snow covering. The low habit is also a protection against excessive water loss during the dry summer months, the more so that most of the lowland species with this habit grow amongst other vegetation and are much protected by it.

The 521 species are all Dicotyledons and the following families contribute each 10 or more: *Caryophyllaceae* (170), *Cruciferae* (31),

Crassulaceae (33), *Saxifragaceae* (21), *Linaceae* (13), *Polygalaceae* (10), *Euphorbiaceae* (20), *Hypericaceae* (22), *Labiatae* (97), *Scrophulariaceae* (15), *Rubiaceae* (25), *Campanulaceae* (15).

13. *Cushion plants.* The definition [1] of cushion plants accepted here is the restricted one given by Hauri and Schröter (1914). On this basis at most only 18 species can be included. These belong to the following families: *Caryophyllaceae* (6), *Saxifragaceae* (7), *Primulaceae* (2), *Rubiaceae* (3). Nearly all of these are high mountain species, though a few extend down to the montane zone, and the habit is one which enables the plants to expose a minimum surface to wind exposure and ensures any protection in winter which can be derived from a snow covering. They are all plants of rocks or very stony ground and are represented in all the districts with high mountains.

14. *Rosette plants.* This category includes both biennials and perennials but has otherwise been defined in the narrow sense of plants with the leaves in basal rosettes from the centre of which an inflorescence or flower-stalk arises whose axis bears no developed foliage leaves. The plants are hemicryptophytes, and there is not always a sharp line separaing them from the subrosette plants where the inflorescence axis above the basal rosette bears cauline foliage leaves. The total of 233 species is a fairly large one for so definite a life-form, but 94 are contributed by the one family *Compositae*. The habit is probably always due to the reduction of subrosette species whose cauline leaves have become mere scales or have entirely ceased to develop. In a few species the inflorescence axis has itself been much shortened relative to the size of the whole plant. In addition to the *Compositae* the following families contribute more than 10 species each: *Violaceae* (16), *Primulaceae* (21), *Plumbaginaceae* (33), *Plantaginaceae* (16).

15. *Herbaceous climbing (twining) plants, generally dying down each year.* This is a very limited group which is the herbaceous equivalent of the lianes. They number only 12 species and form a very minor group in the vegetation of our area. The weak herbaceous stems reach the light by twining round supports. No detailed estimate has been made of the numbers of species provided with tendrils and other means of climbing, but these are fairly numerous in the family *Leguminosae*.

[1] Cushion plants are perennial, herbaceous, or woody, mostly evergreen, chamaephytes of spherical, hemispherical, or flat imbricate, compact growth. Their branches are numerous, short, and thickly clothed far down with small sessile leaves, which decompose in various ways; the branches end in a continuous surface and are either thickly pressed one to another or are bound together by dead, largely organic packing material. The plant thus forms a living, spongy cushion, characterized by firmness, compactness, and closed growth, which reacts as a whole to the environmental factors.

16. *Perennial herbs dying down yearly, with perennial buds on thick stock at ground level.* This group includes the typical hemicryptophytes of Raunkiaer's classification, but excludes the true rosette species, the herbaceous twiners, the grasses and grass-like plants, and the rush and sedge forms, while including some of the helophytes of Raunkiaer's HH group. In spite of these exclusions from the hemicryptophyte category in the wide sense, this category, even as here reduced, includes 2,554 species, by far the greatest number of any category in our scheme. Members of the category occur in all the altitudinal zones and in both the Mediterranean and Central European domains, though they markedly exceed the annuals only in the latter and in the transitional districts. Winter cold, rather than summer drought, is the chief climatic factor with which they are correlated. The morphological diversity within the category is considerable and species are included which are subrosette plants, plants with most of the foliage leaves cauline, plants with stolons, and plants with superficial rhizomes. The following families contribute 10 or more species to this category: *Iridaceae* (18), *Santalaceae* (11), *Polygonaceae* (26), *Caryophyllaceae* (113), *Ranunculaceae* (123), *Cruciferae* (167), *Crassulaceae* (11), *Saxifragaceae* (15), *Rosaceae* (80), *Leguminosae* (204), *Geraniaceae* (24), *Linaceae* (16), *Polygalaceae* (12), *Euphorbiaceae* (14), *Malvaceae* (19), *Hypericaceae* (31), *Violaceae* (27), *Oenotheraceae* (17), *Umbelliferae* (248), *Gentianaceae* (17), *Asclepiadaceae* (10), *Borraginaceae* (95), *Labiatae* (152), *Scrophulariaceae* (156), *Rubiaceae* (26), *Valerianaceae* (17), *Dipsacaceae* (51), *Campanulaceae* (108), *Compositae* (629).

17. *Geophytes.* These are plants with the perennial buds below the level of the soil. In contrast with the estimates under Raunkiaer's system as given above, the grass and grass-like species are not included. In the Mediterranean domain this habit is correlated with summer drought. Transpiration is reduced, relative to the intake of water by the roots, by the aerial parts dying down in summer, and food reserves made in winter and spring are stored in the subterranean parts. A considerable number of geophytes of the Mediterranean domain are bulbous plants of summer dry habitats, especially of the phrygana, while many of those of the Central European domain are rhizomatous or tuberous species of deciduous woodlands. Spring is the chief flowering season, but a number of geophytic species flower in the autumn. The time of appearance of the green leaves varies, but many species of this category are winter green as, for example, *Muscari neglectum* Guss. and *Ornithogalum refractum* Kit. The families with 10 or more species in this category are: *Araceae* (10), *Liliaceae* (235), *Amaryllidaceae* (23), *Iridaceae* (43), *Orchidaceae* (91), *Aristolochiaceae* (10), *Ranunculaceae* (17), *Umbelliferae* (18), *Primulaceae* (11), *Orobanchaceae* (37).

18. *Therophytes*. This category consists of annual plants only and is exactly the same as the group in the Raunkiaer scheme.

19. *Hydrophytes*. There are counted here only the true, completely aquatic plants, totalling 70 species. These are best represented in the Central European domain of the Balkan Peninsula. The vast majority are perennials of wide general distribution, and show the same varied methods of winter survival as in all other areas of the North Temperate Zone. The families contributing most species are: *Potamogetonaceae* (27), *Lemnaceae* (5), *Ranunculaceae* (8), *Callitrichaceae* (7), *Lentibulariaceae* (5).

20. *Parasites and saprophytes*. The parasites may be subdivided as follows: (i) The woody hemiparasites of trees and shrubs, including *Arceuthobium oxycedri* Bieb., *Loranthus europaeus* Jacq., and *Viscum album* L. (ii) The herbaceous hemiparasites, including species of *Santalaceae* (17), and *Scrophulariaceae* (*Rhinantheae*) (93). (iii) The complete parasites, including *Cytinus hypocistis* L., *Cynomorium coccineum* L., *Cuscuta* (10), *Orobanchaceae* (41). The species vary much in their dependence on specific hosts. *Arceuthobium oxycedri* nearly always occurs on junipers, chiefly on *Juniperus oxycedrus* L., and *Cytinus hypocistis* on species of *Cistus*. *Loranthus europaeus* and *Viscum album* have a wide range of hosts, while some of the species of *Orobanche* and *Cuscuta* are limited in their hosts and others succeed on many different species. The complete phanerogamic saprophytes of our flora are not numerous, including only two species of orchids and *Monotropa hypopitys* L.

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V

FLOWERING PERIODS

General. Full phenological data are not yet available for the Balkan Peninsular flora. Field observations on the subject have been made especially by the present author and his friend Mr. B. Gilliat-Smith on as many species as possible, while much information has been gleaned from herbarium labels and floristic works. The accuracy of the data available is not questioned, it is their incompleteness which is disappointing and may eventually necessitate rather considerable alterations in the figures given below. These alterations will, however, all be increases in the number of species known to flower each month in the Balkan Peninsula, and probably the increases will have values proportional to the figures now given for each month.

The figures are for the Balkan Peninsula as a whole. It is impossible at present to compare the phenology of the districts, except in a generalized manner. Thus the majority of the species of the Mediterranean flora flower earlier than the bulk of the species in the Central European domain. The lowland and hill floras have their dominant flowering periods before those of the higher altitudinal zones in both domains. The flowering period is a character of definite taxonomic value in certain species of the section, *Pseudo-lysimachia* Koch of the genus *Veronica*, in *Crocus*, *Colchicum*, and some other genera. On the other hand the flowering period of species with a considerable range in latitude or altitude is usually a long one. Thus *Crocus veluchensis* Herb. on the Vitoša and Rodope in Bulgaria can be found in flower from May at the lower altitudes, till August at the higher. I found the floral succession a very striking feature in South Macedonia,[1] and Gilliat-Smith was similarly impressed in Eastern Bulgaria. From observations made while cultivating numerous species from the Balkan Peninsula I have drawn the general conclusion that characteristic Mediterranean species usually flower a few weeks later and remain longer in bloom under open-air cultivation at Kew than in their native habitats. Central European species in general approximate more closely at Kew to their flowering period in their natural habitat, though a few exceptions have been noted. Further experiments on this subject are now in hand.

[1] Turrill in *Kew Bull.* 1918, pp. 257–9.

SPECIES OF EACH FAMILY FLOWERING EACH MONTH

Months:	1	2	3	4	5	6	7	8	9	10	11	12
Taxaceae	..	..	..	1	1	..	..	..	..	..	..	..
Pinaceae	4	4	6	11	13	3	..	..	..	..	3	3
Gnetaceae	..	2	2	3	3	2	..	..	..	..	..	..
Typhaceae	..	..	..	..	1	2	5	4	..	..	..	..
Sparganiaceae	..	..	..	..	..	5	5	4	..	..	..	..
Potamogetonaceae	..	..	..	2	7	26	25	23	7	..	..	..
Naiadaceae	..	..	..	..	..	1	1	2	2	..	..	..
Scheuchzeriaceae	..	..	..	2	2	3	2	1	2	1	1	..
Alismataceae	..	..	..	1	2	3	5	5	3	11	..	..
Butomaceae	..	..	..	..	1	1	1	1	..	..	..	..
Hydrocharitaceae	..	..	..	..	1	2	2	2	1	1	..	..
Gramineae	1	2	17	99	209	265	220	113	48	19	4	2
Cyperaceae	..	1	8	35	82	97	78	48	27	9	3	1
Araceae	2	2	3	7	9	4	1	..	..	2	2	2
Lemnaceae	..	..	..	..	4	4	3	3	..	..	..	..
Juncaceae	..	..	1	4	13	32	31	23	12	2	..	..
Liliaceae	7	14	52	92	105	86	73	49	23	20	11	5
Amaryllidaceae	2	7	11	12	3	..	..	..	6	6	4	5
Dioscoreaceae	..	..	1	1	2	2	..	..	..	..	..	..
Iridaceae	2	20	20	18	22	20	7	..	3	10	13	3
Orchidaceae	1	3	26	43	59	51	32	14	4	..	..	1
Salicaceae	..	1	13	18	11	8	6	..	..	..	..	..
Juglandaceae	..	..	..	1	1	..	..	..	..	..	..	..
Betulaceae	..	3	5	8	6	2	1	1	..	..	..	..
Fagaceae	..	..	..	9	16	4	1	..	..	..	..	..
Ulmaceae	..	..	4	5	3	..	..	..	..	..	..	..
Moraceae	..	..	..	..	..	..	2	1	1	..	..	..
Urticaceae	1	4	5	5	6	7	8	4	4	1	1	1
Loranthaceae	..	..	1	2	1	1	..	..	..	..	..	..
Santalaceae	..	..	1	1	6	9	11	7	..	..	..	..
Aristolochiaceae	..	..	3	10	11	5	3	..	..	..	..	..
Rafflesiaceae	..	..	1	1	1	6	..	..	..	..	..	..
Polygonaceae	..	1	3	5	13	30	39	37	22	8	2	1
Chenopodiaceae	..	..	..	1	5	8	48	56	50	15	3	..
Amarantaceae	..	..	..	..	1	1	7	7	7	5	..	..
Cynocrambaceae	1	1	1	1	1	..	..	..	..	..	..	1
Phytolaccaceae	..	..	..	..	..	..	1	1	1	..	..	..
Aizoaceae	..	..	..	4	3	3	4	2	2	..	..	..
Portulacaceae	..	..	..	..	2	2	2	1	1	..	..	..
Caryophyllaceae	1	4	26	84	178	254	273	155	25	5	3	2
Nymphaeaceae	..	..	..	..	2	4	4	2	..	..	..	..
Ceratophyllaceae	..	..	..	..	..	3	3	2	2	..	..	..
Ranunculaceae	4	10	38	67	95	94	62	25	5	1	2	1
Berberidaceae	1	1	1	3	5	1	..	..	..	..	..	..
Lauraceae	..	..	1	1	..	..	..	..	..	..	..	..

SPECIES OF EACH FAMILY FLOWERING EACH MONTH (*continued*)

Months:	1	2	3	4	5	6	7	8	9	10	11	12
Papaveraceae.	..	..	18	33	37	20	8	2	1	..	..	..
Cruciferae	5	15	62	151	221	196	114	36	12	4	4	4
Capparidaceae	..	..	..	..	2	2	2	2	..	..	..	..
Resedaceae	..	..	2	4	8	7	4	1	..	..	..	..
Droseraceae	..	..	..	..	..	1	2	1	..	..	..	..
Crassulaceae	1	1	3	10	20	34	27	14	2	..	..	..
Saxifragaceae.	..	..	2	6	13	26	29	12	4	..	..	..
Platanaceae	..	..	1	1	1	..	..	..	..	..	..	..
Rosaceae	1	2	16	39	83	111	91	43	11	..	..	..
Leguminosae.	2	6	100	231	362	307	199	76	8	1	1	..
Geraniaceae	2	2	10	18	30	30	24	11	3	..	2	2
Oxalidaceae	1	1	1	2	2	1	1	1	1	..	..	..
Linaceae	..	..	..	7	16	27	23	6	1	..	..	..
Zygophyllaceae	..	..	..	2	3	4	3	2	2	2	1	1
Rutaceae	..	..	3	3	9	10	6	..	..	..	..	..
Polygalaceae	..	..	1	4	8	10	7	2	..	..	..	..
Euphorbiaceae	2	6	17	31	48	48	35	13	9	5	3	..
Callitrichaceae	..	..	1	2	7	7	4	4	1	..	..	..
Buxaceae	..	..	1	1	1	1	..	..	..	..	..	..
Empetraceae	..	..	..	1	1	..	..	..	..	..	..	..
Coriariaceae	..	..	..	1	1	..	..	..	..	..	..	..
Anacardiaceae	..	..	1	2	4	2	..	..	..	..	..	..
Aquifoliaceae.	..	..	..	..	1	1	..	..	..	..	..	..
Celastraceae	..	..	..	1	4	2	..	..	..	..	..	..
Staphyleaceae	..	..	..	..	1	..	..	..	..	..	..	..
Aceraceae	..	..	..	6	9	1	..	..	..	..	..	..
Hippocastanaceae	..	..	..	..	1	1	..	..	..	..	..	..
Balsaminaceae	..	..	..	..	..	..	1	1	1	..	..	..
Rhamnaceae	..	..	2	4	12	12	5	..	..	..	..	..
Vitaceae	..	..	..	..	1	1	..	..	..	..	..	..
Tiliaceae	..	..	..	..	1	4	3	..	..	..	..	..
Malvaceae	..	..	2	13	17	18	19	10	5	..	..	..
Hypericaceae.	..	2	3	4	16	27	31	14	1	..	..	..
Elatinaceae	..	..	..	..	1	2	2	1	1	..	..	..
Frankeniaceae	..	..	..	1	1	1	1	..	..	..	..	..
Tamaricaceae	..	..	1	4	6	4	3	1	1	..	..	..
Cistaceae	..	..	4	14	26	19	10	2	..	..	..	..
Violaceae	..	1	7	15	25	19	21	10	..	..	..	..
Datiscaceae	..	..	..	..	..	..	1	..	..	..	..	..
Thymelaeaceae	1	2	3	7	7	7	8	4	2	1	1	1
Elaeagnaceae	..	..	..	1	2	1	..	..	..	..	..	..
Lythraceae	..	..	..	2	4	4	8	5	1	..	..	..
Punicaceae	..	..	..	..	1	1	..	..	..	..	..	..
Myrtaceae	..	..	..	..	..	1	1	1	1	..	..	..
Oenotheraceae	..	..	..	..	..	4	20	18	7	..	..	..
Hippuridaceae	..	..	..	..	..	3	3	3	..	..	..	..
Cynomoriaceae	..	..	1	1	1	1	..	..	..	..	..	..

SPECIES OF EACH FAMILY FLOWERING EACH MONTH (*continued*)

Months:	1	2	3	4	5	6	7	8	9	10	11	12
Araliaceae	..	..	..	..	..	..	..	..	..	2	2	..
Umbelliferae	..	..	6	33	82	153	211	134	36	5	1	..
Cornaceae	..	..	1	1	1	1	..	..	..	..	..	..
Pirolaceae	..	..	..	..	3	5	5	3	..	..	..	..
Ericaceae	2	2	4	5	10	8	6	6	3	2	2	2
Primulaceae	1	3	7	13	19	25	23	10	8	7	5	1
Plumbaginaceae	..	..	1	1	9	21	34	27	10	6	2	..
Ebenaceae	..	..	..	..	1	1	1	1	..	..	..	..
Styracaceae	..	..	..	1	1	..	..	..	..	..	..	..
Oleaceae	..	..	5	10	9	6	1	..	..	..	..	..
Gentianaceae	..	..	..	3	8	15	26	20	10	3	..	..
Apocynaceae	..	2	3	5	4	2	1	2	..	..	..	..
Asclepiadaceae	..	..	..	1	4	11	8	3	..	..	..	..
Convolvulaceae	..	..	1	6	18	21	22	13	..	..	..	..
Polemoniaceae	..	..	..	..	..	1	1	..	..	..	..	..
Borraginaceae	..	6	30	65	101	87	60	21	7	2	2	..
Verbenaceae	..	..	..	..	1	4	4	3	2	1	..	..
Labiatae	1	5	26	66	140	208	225	131	35	14	4	1
Solanaceae	2	5	6	10	14	13	11	6	5	3	1	1
Scrophulariaceae	2	12	23	50	99	162	188	120	41	6	1	1
Orobanchaceae	..	..	..	15	24	22	17	8	3	1	..	..
Gesneriaceae	..	..	..	2	4	4	2	2	1	..	..	..
Lentibulariaceae	..	..	..	1	3	6	3	2	1	..	..	..
Globulariaceae	..	1	1	1	4	3	1	..	1	..	..	..
Acanthaceae	..	..	..	..	2	4	4	..	..	..	..	..
Plantaginaceae	..	2	3	10	17	19	17	11	5	2	..	..
Rubiaceae	..	1	5	19	52	84	76	44	7	..	..	..
Caprifoliaceae	..	..	1	4	11	13	7	1	..	..	..	..
Adoxaceae	..	..	1	1	1	..	..	..	..	..	..	..
Valerianaceae	..	2	7	21	23	19	14	9	2	1	..	..
Dipsacaceae	..	..	1	3	8	35	59	46	15	..	..	..
Cucurbitaceae	..	..	1	3	5	3	3	3	2	..	..	..
Campanulaceae	..	..	1	18	38	72	101	64	8	2	1	..
Compositae	9	16	51	119	266	424	588	382	117	27	13	7

TOTALS

Months:	1	2	3	4	5	6	7	8	9	10	11	12
Gymnospermae	4	6	8	15	17	5	..	..	..	..	3	3
Monocotyledoneae	15	49	139	316	522	604	491	292	138	81	38	19
Dicotyledoneae	40	120	550	1335	2363	2872	2910	1669	514	132	57	27
	59	175	697	1666	2902	3481	3401	1961	652	213	98	49

Conclusions. June is the month with most species in flower, though the records are only eighty less for July. The largest number of Monocotyledons are in flower in June, and of Dicotyledons in July. During either of these two months more than half the species of the entire flora may be found in bloom.

The following important families in the Balkan Peninsular flora have a majority of species flowering in the spring: *Pinaceae*, *Liliaceae*, *Amaryllidaceae*, *Iridaceae*, *Orchidaceae*, *Salicaceae*, *Betulaceae*, *Fagaceae*, *Ranunculaceae*, *Papaveraceae*, *Cruciferae*, *Leguminosae*, *Cistaceae*, *Violaceae*, *Oleaceae*, and *Borraginaceae*. The following are predominantly summer flowering: most of the aquatic families, as the *Potamogetonaceae*, also the *Gramineae*, *Cyperaceae*, *Juncaceae*, *Polygonaceae*, *Caryophyllaceae*, *Crassulaceae*, *Saxifragaceae*, *Rosaceae*, *Linaceae*, *Malvaceae*, *Hypericaceae*, *Oenotheraceae*, *Umbelliferae*, *Primulaceae*, *Plumbaginaceae*, *Gentianaceae*, *Labiatae*, *Scrophulariaceae*, *Plantaginaceae*, *Rubiaceae*, *Dipsacaceae*, *Campanulaceae*, and *Compositae*. The seacoast plants are amongst the latest flowerers, and this is reflected in the high figures for late summer and autumn of the *Chenopodiaceae*.

I find no evidence for the view that the species of genera or families predominantly tropical are on the whole late in flowering. There is some slight evidence in favour of the view that species of families supposed, according to the latest phylogenetic hypotheses, to be primitive on the average flower earlier than those supposed to be highly evolved.

VI

HABITAT CLASSIFICATION

System used. The habitats, so far as they are known, of each species of the Balkan Peninsular flora have been tabulated, and the results are summarized for each family in the following table. The empirical classification which has been used is as follows: (1) Sea. (2) Freshwater. (3) Marshes and sides of ditches, streams, rivers, lakes, and ponds, and near springs. (4) Bogs. (5) Woods and forests (as trees, undergrowth, or ground-flora). (6) Brushwood (as shrub-layer or ground-flora). (7) Grassy places, meadows, and pastures. (8) Sandy places. (9) Stony and dry places, especially dry hill-slopes. (10) Stony and rocky humid places. (11) Dry rocks and walls and their crevices. (12) Melting snow. (13) Arable fields and gardens (weeds of cultivation). (14) Vineyards. (15) Olive groves. (16) Ruderal places.

It is obvious that these habitats may merge and overlap and that a species may occur in more than one of them. When this happens, all the known habitats for any species have been counted in the total figures. The figures for habitats 10 and 12 will probably be increased when more observations have been made.

THE NUMBER OF SPECIES IN EACH FAMILY OCCURRING IN THE HABITATS NAMED

	1. *Sea*	2. *Freshwater*	3. *Marshes*	4. *Bogs*	5. *Forests*	6. *Brushwood*	7. *Grassy places*	8. *Sandy places*	9. *Stony dry places*	10. *Stony humid places*	11. *Dry rocks and walls*	12. *Melting snow*	13. *Arable land*	14. *Vineyards*	15. *Olive groves*	16. *Ruderal places*
Taxaceae	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..
Pinaceae	..	..	..	..	14	8	..	..	..	..	..	..	..	..	..	..
Gnetaceae	..	..	..	..	..	1	..	1	1	..	3	..	..	..	..	..
Typhaceae	..	..	6	..	..	..	..	..	..	..	..	..	..	..	..	..
Sparganiaceae	..	..	5	..	..	..	..	..	..	..	..	..	..	..	..	..
Potamogetonaceae	5	23	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Naiadaceae	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Scheuzeriaceae	..	..	3	..	..	..	..	1	..	1	..	..	..	..	..	..
Alismataceae	..	..	6	..	..	..	..	..	..	..	..	..	..	..	..	..
Butomaceae	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..
Hydrocharitaceae	..	3	1	..	..	..	..	..	..	..	..	..	..	..	..	..
Gramineae	..	1	31	3	37	26	112	81	113	5	42	..	36	2	2	22
Cyperaceae	..	..	75	12	23	17	39	16	15	5	4	..	1	1	..	..
Araceae	..	1	2	..	..	4	1	..	7	..	..	..	..	..	2	..
Lemnaceae	..	5	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Juncaceae	..	..	25	4	8	..	11	4	3	..	1	..	..	..	..	..
Liliaceae	..	..	2	1	32	57	67	18	107	3	20	2	25	6	6	..
Amaryllidaceae	..	..	2	..	5	5	9	1	12	..	1	..	..	2	..	..
Dioscoreaceae	..	..	..	..	2	1	..	..	1	..	..	..	..	..	..	..
Iridaceae	..	..	2	..	3	17	21	6	34	3	5	3	..	..	..	..
Orchidaceae	..	..	11	..	22	17	60	3	39	..	1	..	..	..	1	..
Salicaceae	..	..	19	1	6	6	6	..	3	..	..	..	..	..	..	..
Juglandaceae	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..
Betulaceae	..	..	1	..	9	4	..	..	1	..	1	..	..	..	..	..
Fagaceae	..	..	..	..	17	5	..	..	2	..	1	..	..	..	..	..
Ulmaceae	..	..	..	..	5	4	..	..	1	..	..	..	..	..	..	..
Moraceae	..	..	..	..	..	1	..	..	1	..	1	..	..	..	..	..
Urticaceae	..	..	..	..	1	..	..	..	..	..	4	..	..	..	..	8
Loranthaceae	..	..	..	..	2	1	..	..	..	..	..	..	..	..	..	..
Santalaceae	..	..	..	..	3	4	5	1	8	..	2	..	3	..	..	..
Aristolochiaceae	..	..	..	..	3	8	1	1	3	..	2	..	2	1	..	..
Rafflesiaceae	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..
Polygonaceae	..	1	12	..	7	5	14	9	7	..	6	..	11	..	1	10
Chenopodiaceae	..	..	10	..	..	..	7	29	12	..	5	..	17	2	..	23
Amarantaceae	..	..	..	..	..	..	..	..	..	..	..	..	5	..	..	7
Cynocrambaceae	..	..	..	..	..	..	..	..	1	..	1	..	1	..	1	1
Phytolaccaceae	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Aizoaceae	..	..	..	..	..	..	1	4	..	..	1	..	1	..	..	3

THE NUMBER OF SPECIES IN EACH FAMILY OCCURRING IN THE HABITATS NAMED (*continued*)

	1. *Sea*	2. *Freshwater*	3. *Marshes*	4. *Bogs*	5. *Forests*	6. *Brushwood*	7. *Grassy places*	8. *Sandy places*	9. *Stony dry places*	10. *Stony humid places*	11. *Dry rocks and walls*	12. *Melting snow*	13. *Arable land*	14. *Vineyards*	15. *Olive groves*	16. *Ruderal places*
Portulacaceae	..	..	..	..	..	..	2	1	..	..	..	..	1	..	..	..
Caryophyllaceae	..	..	10	1	26	41	110	52	149	6	131	..	29	15	1	6
Nymphaeaceae	..	4	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Ceratophyllaceae	..	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Ranunculaceae	..	5	17	1	36	52	52	3	65	10	15	3	28	3	1	4
Berberidaceae	..	..	..	..	2	5	..	..	1	..	..	..	1	..	..	..
Lauraceae	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..
Papaveraceae	..	..	..	..	5	13	1	3	15	..	6	1	..	6	3	6
Cruciferae	..	..	25	1	33	18	52	22	127	5	108	1	43	6	5	40
Capparidaceae	..	..	..	..	..	..	..	..	2	..	1	..	2	..	..	2
Resedaceae	..	..	..	..	..	..	3	1	4	..	1	..	3	2	..	1
Droseraceae	..	1	..	2	..	..	..	..	..	..	..	..	..	..	..	..
Crassulaceae	..	..	1	..	1	2	5	25	1	..	41	..	..	..	..	..
Saxifragaceae	..	..	3	..	4	2	..	..	16	9	30	..	..	..	..	..
Platanaceae	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..
Rosaceae	..	..	3	..	60	70	42	3	43	..	..	..	..	..	..	..
Leguminosae	..	..	15	..	59	114	189	57	221	2	57	..	73	10	7	24
Geraniaceae	..	..	..	..	12	10	19	5	8	..	10	..	2	..	..	2
Oxalidaceae	..	..	..	..	1	..	..	..	..	..	1	..	2	..	1	2
Linaceae	..	..	1	..	3	4	15	2	16	1	5	..	1	..	1	2
Zygophyllaceae	..	..	..	..	..	..	..	1	2	..	..	..	2	..	..	2
Rutaceae	..	..	..	..	1	3	3	..	10	..	3	..	1	..	..	2
Polygalaceae	..	..	..	..	..	3	12	..	4	..	1	..	..	..	..	..
Euphorbiaceae	..	..	3	..	9	10	11	3	27	..	10	..	21	6	3	8
Callitrichaceae	..	7	4	..	..	..	..	..	..	..	..	..	..	..	..	..
Buxaceae	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..
Empetraceae	..	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..
Coriariaceae	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..
Anacardiaceae	..	..	..	..	..	5	..	..	..	..	..	..	..	..	..	..
Aquifoliaceae	..	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..
Celastraceae	..	..	..	..	2	1	..	..	..	..	1	..	..	..	..	..
Staphyleaceae	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..
Aceraceae	..	..	..	..	9	5	..	..	..	..	..	..	..	..	..	..
Hippocastanaceae	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..
Balsaminaceae	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..
Rhamnaceae	..	..	..	..	1	10	..	..	8	..	9	..	..	1	..	..
Vitaceae	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..
Tiliaceae	..	..	..	..	4	..	..	..	..	..	1	..	..	..	..	..

THE NUMBER OF SPECIES IN EACH FAMILY OCCURRING IN THE HABITATS NAMED (*continued*)

	1. *Sea*	2. *Freshwater*	3. *Marshes*	4. *Bogs*	5. *Forests*	6. *Brushwood*	7. *Grassy places*	8. *Sandy places*	9. *Stony dry places*	10. *Stony humid places*	11. *Dry rocks and walls*	12. *Melting snow*	13. *Arable land*	14. *Vineyards*	15. *Olive groves*	16. *Ruderal places*
Malvaceae	..	..	1	..	3	9	4	2	10	..	2	..	9	1	1	10
Hypericaceae	..	..	1	..	9	13	15	..	14	..	8	..	..	1	1	..
Elatinaceae	..	..	5	..	..	..	..	..	..	..	..	..	..	..	..	..
Frankeniaceae	..	..	..	..	..	..	..	1	2	..	..	..	..	..	..	..
Tamaricaceae	..	..	6	..	..	1	..	1	1	..	..	..	..	1	..	..
Cistaceae	..	..	..	..	2	10	4	3	16	..	..	..	..	..	..	..
Violaceae	..	..	1	..	9	6	22	1	16	2	12	2	1	1	..	..
Datiscaceae	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..
Thymelaeaceae	..	..	..	..	4	8	2	1	4	..	6	..	2	..	..	..
Elaeagnaceae	..	..	..	..	..	..	..	2	1	..	..	..	..	..	..	..
Lythraceae	..	..	10	..	..	..	..	..	..	..	..	..	1	..	..	..
Punicaceae	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..
Myrtaceae	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..
Oenotheraceae	..	1	12	..	7	4	2	..	2	1	..	..	..	..	..	..
Hippuridaceae	..	3	1	..	..	..	..	..	..	..	..	..	..	..	..	..
Cynomoriaceae	..	..	..	..	..	1	..	..	1	..	..	..	..	..	..	..
Araliaceae	..	..	..	..	1	1	..	..	1	..	2	..	..	..	..	..
Umbelliferae	..	2	27	..	42	64	95	11	98	..	65	..	37	16	9	10
Cornaceae	..	..	..	..	2	3	..	..	..	..	..	..	..	..	..	..
Pirolaceae	..	..	..	..	7	..	..	..	..	..	..	..	..	..	..	..
Ericaceae	..	..	1	..	5	11	4	..	3	..	4	..	..	..	..	..
Primulaceae	..	2	7	..	11	12	14	7	13	7	7	3	3	..	..	1
Plumbaginaceae	..	..	..	..	..	1	5	14	12	..	10	..	1	..	..	1
Ebenaceae	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..
Styracaceae	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..
Oleaceae	..	..	..	..	9	12	..	..	4	..	1	..	..	..	..	..
Gentianaceae	..	1	3	..	4	5	32	1	9	..	..	..	..	..	..	..
Apocynaceae	..	..	1	..	1	4	1	1	2	..	..	..	..	..	..	..
Asclepiadaceae	..	..	1	..	2	6	1	..	5	..	..	..	..	..	..	1
Convolvulaceae	..	..	4	..	2	8	13	3	9	..	5	..	2	..	..	..
Polemoniaceae	..	..	..	..	..	..	1	..	1	..	..	..	..	..	..	..
Borraginaceae	..	..	6	..	17	17	34	21	61	1	30	..	20	6	..	15
Verbenaceae	..	..	2	..	..	1	1	2	..	..	..	..	..	..	..	2
Labiatae	..	..	15	..	39	68	63	6	169	..	83	..	25	3	3	17
Solanaceae	..	..	..	..	3	3	3	..	6	..	1	..	3	..	..	7
Scrophulariaceae	..	..	22	..	35	35	105	14	80	3	43	2	30	8	1	6
Orobanchaceae	..	..	..	..	4	7	21	1	11	..	2	..	7	..	..	..
Gesneriaceae	..	..	..	..	..	..	..	..	1	..	5	..	..	..	..	..

THE NUMBER OF SPECIES IN EACH FAMILY OCCURRING IN THE HABITATS NAMED (*continued*)

	1. *Sea*	2. *Freshwater*	3. *Marshes*	4. *Bogs*	5. *Forests*	6. *Brushwood*	7. *Grassy places*	8. *Sandy places*	9. *Stony dry places*	10. *Stony humid places*	11. *Dry rocks and walls*	12. *Melting snow*	13. *Arable land*	14. *Vineyards*	15. *Olive groves*	16. *Ruderal places*
Lentibulariaceae	..	5	..	1	..	..	3	..	..	2	..	..	..	..	..	..
Globulariaceae	..	..	..	..	..	2	1	..	3	..	3	..	..	..	..	..
Acanthaceae	..	..	..	..	3	..	..	..	1	..	..	..	2	1	..	1
Plantaginaceae	..	1	3	..	..	..	11	8	10	..	3	..	4	..	..	..
Rubiaceae	..	..	5	1	18	21	17	3	41	1	48	..	10	4	1	1
Caprifoliaceae	..	..	2	..	6	10	..	..	3	..	3	..	..	..	..	..
Adoxaceae	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..
Valerianaceae	..	..	3	..	2	..	17	..	10	2	10	..	10	..	..	..
Dipsacaceae	..	..	1	..	7	12	27	4	27	..	20	..	7	1	2	3
Cucurbitaceae	..	..	..	..	..	5	..	1	1	..	1	..	..	..	..	1
Campanulaceae	..	..	2	..	11	13	33	..	50	..	68	..	6	..	..	..
Compositae	..	..	46	1	100	105	274	55	315	12	166	1	106	28	7	67

The figures in the above table add up as follows:

Gymnospermae	..	..	..	..	15	9	..	1	1	..	3	..	..	..	..	..
Monocotyledoneae	5	35	172	20	132	144	320	130	331	17	74	5	62	11	11	22
Dicotyledoneae	..	36	314	9	697	898	1371	365	1795	65	1063	13	535	123	49	297
Angiospermae	5	71	486	29	829	1042	1691	495	2126	82	1137	18	597	134	60	319
Phanerogamae	5	71	486	29	844	1051	1691	496	2127	82	1140	18	597	134	60	319

ANALYSES OF THE TABLES

If the habitats are arranged according to the numbers of species occurring in them the following is the result:

9. Stony and dry places, with 2,127 species.
7. Grassy places, meadows, and pastures, with 1,691 species.
11. Dry rocks and walls and their crevices, with 1,140 species
6. Brushwood, with 1,051 species.
5. Woods and forests, with 844 species.
13. Arable fields and gardens, with 597 species.
8. Sandy places, with 496 species.

3. Marshes and sides of streams, rivers, lakes, and ponds, and near springs, with 486 species.
16. Ruderal places, with 319 species.
14. Vineyards, with 134 species.
10. Stony and rocky humid places, with 82 species.
2. Freshwater, with 71 species.
15. Olive groves, with 60 species.
4. Bogs, with 29 species.
12. Melting snow, with 18 species.
1. Sea, with 5 species.

These figures give additional emphasis to facts established in the chapter on the influence of man on the vegetation and flora of the Balkan Peninsula. The commonest habitats, as based on species numbers, are those which most frequently result from the destruction of woods and forests in the Balkan Peninsula. I have no means of computing the absolute or relative areas covered by these habitats and the associations characteristic of them, but many field botanists in the Peninsula, and especially those also familiar with vegetation conditions under an oceanic climate, have been struck with the wide extents of stony dry hill slopes, of open 'grassland', rock exposure, and of brushwood, correlated with the limitation of high forest to the more inaccessible areas, not always the climatically and edaphically most favourable. Woods and forests are still numerous, especially in the montane and first high mountain altitudinal zones, and remnants occur at all altitudes below the forest limit. Nevertheless, the abundance and distribution of woodland species, whether of the tree-layer, the undergrowth, or the ground-flora, must have been much curtailed by man's activities. On the other hand, the destruction of forests has led to a great increase in the extent of other habitats and especially of those with the highest number of species. Indeed, all the evidence points to the conclusion that this extension of deforested land has enabled certain genera to increase not merely their area of distribution but the numbers of their species. This conclusion does not necessarily involve the assumption that the habitat conditions have themselves occasioned germinal modifications leading to species-formation. It is most probable that the morphological differences between taxonomic species are not all due to the same cause. The more numerous are the individuals of a species the more likely are mutations to occur in it. Hybridization and the segregation of new groups will occur more often if species and varieties mix over wider areas. It is significant that many of the largest genera in the Balkan Peninsular flora have many species which flourish in just the habitats produced by forest destruction. Excellent examples are: *Centaurea*, *Dianthus*, *Silene*, *Verbascum*, and *Veronica*.

The marsh plants total 486 species. A majority of these occur in the Central European domain. The conclusion derived from a study of the distribution of individual species suggests that the marsh and aquatic floras are now less important than they have been in the Balkan Peninsula and especially that the distribution of many species is becoming more and more restricted. Striking examples are *Trapa natans* L. and *Hottonia palustris* L. The artificial draining of lakes and swamps is an important cause of this, but the natural drying out of the remnants of the Pontic lakes has been, over a long geological period of time, a more fundamental cause. Bogs are rare in the Balkan Peninsula and occur only in some of the mountainous parts, hence the small number, 29, of species known from such a habitat.

VII

ALTITUDINAL ZONATION

Altitudinal zonation is obviously closely connected with the classification of vegetation into plant communities. Since, however, there are floristic and distributional aspects, as well as ecological, it has been considered advisable to devote a separate, even if short, chapter to the scheme used in this work, the floristic data, and a short summary of matters of wider interest than can be discussed under the different plant communities.

Scheme adopted. The following division into altitudinal zones or areas has been found most convenient for expressing the vertical range of species.

1. *Coastal belt.* This is obviously dependent on proximity to the sea and is therefore limited to districts within the Mediterranean domain together with parts of South Croatia (15), Istria (16), Thrace (7), and South Bulgaria (8a), the whole of North Bulgaria (8), and the Dobruja (9). It extends only a few metres at most above sea level.

2. *Lowland area.* This term is limited to the plains, which are mostly either under cultivation or are swampy, and to the lowlands of the main river basins. The Thessalian Plain, drained by the river Peneios (Salambria), the Salonika Campania, the Struma Plain, parts of the region round Scutari Lake, the region of the Danube mouths, and the area near the Lower Morava, are examples.

3. *Hill and foothill areas* (partly the 'submontane' of some authors) reaching up to 700–1,000 m. The relatively dry, often stony or rocky slopes of the lower hills are botanically of great importance because they form the commonest type of habitat. Formerly, without doubt, considering the Peninsula as a whole, they were wooded more densely in the Central European domain, more sparsely in the Mediterranean domain. With the destruction of the woods this type of habitat was greatly increased in size, and, since the forests most easily accessible have suffered most, it has resulted that the altitudinal zone from the plains up to 700–1,000 m. is largely represented by bare or scrub-covered hill slopes. 'Scrub' or 'brushwood' is very characteristic of the foothills and the lower hills. In the south of Greece the true macchie reach to 700 or even 1,000 m., but often, and especially farther north as in Macedonia, they are replaced by pseudomacchie and phrygana, and still farther north, and especially in the Central European domain, by shiblyak. The forests when preserved usually consist predominantly of oaks.

4. *Montane area.* Here the forest has more often been preserved and broad-leaved, summer-green trees are dominant. The shiblyak may still occur, more especially in the northern parts of the Mediterranean domain, but dies out in this zone. On an average this zone reaches from 700–1,000 m. up to 1,400–1,500 m. In many districts the beech is a characteristic and dominant tree, but the Greek 'fir' region, usually dominated by *Abies cephalonica*, is also included here.

5. *High mountain area.* This is represented only on the higher mountain masses and is sometimes scarcely further subdivisible. Often however, two or three divisions can be distinguished as follows:

5a. *A lower division* with woods of *Abies*, *Picea*, *Pinus*, and *Fagus silvatica* (on an average from 1,500 to 1,700 m.) Oak woods are absent.

5b. *A middle division*—above the true forest limit, though often with low shrubs and stunted, isolated trees, but most often with rich pastures (on an average from 1,700 to 2,000 m.).

5c. *An upper division* of stony meadows, mats, and rock formations (on an average above 2,000 m.).

Summary and discussion. It is evident from the tables (pp. 113–16) that the most important altitudinal zone floristically is the hill zone, with the montane zone second in numbers of species. These facts are in accord with the physiographic structure of the Balkan Peninsula, which is predominantly a region of hills and mountains, but in which no peak rises above 3,000 m. or 10,000 feet. The fact, established for various mountain groups, that the higher the mountain mass the higher are the altitudinal zones of vegetation, holds for the Balkan Peninsula if allowances are made for differences of latitude. Thus the forest limit is higher in the larger and higher Rodope massif than it is on the Suva Planina, on the Stara Planina, or on the Vitoša. The orientation of the mountains and the position of the plains also affect the limits reached by the botanical zones. Thus the forest is more luxuriant, and closed forest extends higher, on the northern than on the southern slopes of the Stara Planina and Rodope massif. The sheltered Struma plain is one of the most subtropical parts of the Balkan Peninsula—especially in its agricultural crops.

Two kinds of extension of distributional area have to be recognized in this section. The one is 'migration' on approximately the same level. The other a migration upwards or downwards from one altitudinal zone to another. While a considerable number of species extend into more than one zone there are very few in our flora which have no altitudinal limitation. 'Altitude' is ecologically a complex of factors which have varying actions on different species, but the result is that

(*continuation after tables on p. 116*)

The Black Sea coast-line north of Varna, showing the absence of beach, the terrestrial vegetation coming down to the shore, and the great enemy of plant-life—a flock of goats.

The conifer zone east of Rila with *Picea abies* and *Abies alba* at about 1,700 m.

THE ALTITUDINAL DISTRIBUTION OF THE SPECIES IN EACH FAMILY

	1. *Coastal Belt*	2. *Lowland Area*	3. *Hill and Foot-hill Areas*	4. *Montane Area*	5a. *Lower High Mountain Area*	5b. *Middle High Mountain Area*	5c. *Upper High Mountain Area*
Taxaceae	..	..	..	..	1	..	..
Pinaceae	..	6	5	6	11	3	..
Gnetaceae	..	2	1	..	1	..	..
Typhaceae	..	6	..	..	..	..	..
Sparganiaceae	..	2	3	2	..	..	1
Potamogetonaceae	5	16	17	12	12	14	..
Naiadaceae	2	2	..	..	..	..	..
Scheuchzeriaceae	3	2	1	1	..	..	..
Alismataceae	..	6	4	..	..	..	..
Butomaceae	..	1	1	..	..	..	..
Hydrocharitaceae	..	3	1	..	..	..	..
Gramineae	45	205	189	152	66	62	27
Cyperaceae	8	69	81	77	37	27	8
Araceae	..	10	10	7	3	1	..
Lemnaceae	..	5	4	..	..	..	..
Juncaceae	6	19	19	17	10	9	8
Liliaceae	11	118	166	114	44	32	10
Amaryllidaceae	1	6	18	8	4	2	1
Dioscoreaceae	..	1	2	1	..	..	..
Iridaceae	2	29	42	25	5	4	1
Orchidaceae	..	38	77	56	23	13	1
Salicaceae	..	8	13	16	13	12	5
Juglandaceae	..	..	1	1	..	..	..
Betulaceae	..	1	8	8	5	2	..
Fagaceae	..	6	16	11	1	..	..
Ulmaceae	..	3	6	4	..	..	..
Moraceae	..	2	2	2	..	..	..
Urticaceae	..	8	6	3	..	..	..
Loranthaceae	..	3	3	3	..	..	..
Santalaceae	..	6	2	8	3	3	1
Aristolochiaceae	..	8	9	4	..	..	..
Rafflesiaceae	..	1	1	..	..	..	..
Polygonaceae	5	27	30	25	11	11	5
Chenopodiaceae	31	33	28	6	3	2	..
Amarantaceae	..	7	7	..	..	..	..
Cynocrambaceae	..	1	1	..	..	..	..
Phytolaccaceae	..	1	1	..	..	..	..
Aizoaceae	3	5	1	..	..	..	..
Portulacaceae	..	2	2	1	..	..	..
Caryophyllaceae	27	122	214	176	82	101	43

THE ALTITUDINAL DISTRIBUTION OF THE SPECIES IN EACH FAMILY (*continued*)

	1. *Coastal Belt*	2. *Lowland Area*	3. *Hill and Foot-hill Areas*	4. *Montane Area*	5a. *Lower High Mountain Area*	5b. *Middle High Mountain Area*	5c. *Upper High Mountain Area*
Nymphaeaceae	..	3	1	1	..	..	..
Ceratophyllaceae	..	3	..	..	..	..	..
Ranunculaceae	..	69	125	90	47	42	22
Berberidaceae	..	2	5	3	3	1	..
Lauraceae	..	1	1	..	..	..	..
Papaveraceae	3	33	41	13	4	4	2
Cruciferae	26	112	212	151	73	74	41
Capparidaceae	..	3	2	..	..	..	..
Resedaceae	..	2	7	3	..	..	..
Droseraceae	..	1	..	1	1	2	..
Crassulaceae	4	21	27	33	20	17	7
Saxifragaceae	..	..	9	20	19	23	30
Platanaceae	..	1	1	1	..	..	..
Rosaceae	..	45	100	111	55	35	21
Leguminosae	26	257	374	187	77	60	36
Geraniaceae	2	20	25	24	13	14	2
Oxalidaceae	..	2	2	1	1	..	..
Linaceae	1	8	25	20	10	8	6
Zygophyllaceae	2	4	3	..	..	..	..
Rutaceae	..	7	13	5	..	..	..
Polygalaceae	..	3	8	8	4	3	2
Euphorbiaceae	4	44	52	32	11	3	1
Callitrichaceae	1	6	..	..	..	..	..
Buxaceae	..	..	..	1	1	1	..
Empetraceae	..	..	..	..	..	1	1
Coriariaceae	..	1	1	..	..	..	..
Anacardiaceae	..	4	5	2	..	..	..
Aquifoliaceae	..	..	1	1	..	..	..
Celastraceae	..	4	4	4	..	..	..
Staphyleaceae	..	1	1	..	..	..	..
Aceraceae	..	3	4	9	5	..	..
Hippocastanaceae	..	..	1	1	..	..	..
Balsaminaceae	..	..	1	1	1	..	..
Rhamnaceae	..	8	11	9	3	2	1
Vitaceae	..	1	1	..	..	..	..
Tiliaceae	..	..	3	4	..	..	..
Malvaceae	..	26	23	6	1	1	..
Hypericaceae	3	18	31	20	10	7	4
Elatinaceae	..	4	2	1	..	..	..
Frankeniaceae	2	..	..	..	..	..	..

THE ALTITUDINAL DISTRIBUTION OF THE SPECIES IN EACH FAMILY (*continued*)

	1. *Coastal Belt*	2. *Lowland Area*	3. *Hill and Foothill Areas*	4. *Montane Area*	5a. *Lower High Mountain Area*	5b. *Middle High Mountain Area*	5c. *Upper High Mountain Area*
Tamaricaceae	3	7	1	..	..	..	..
Cistaceae	1	16	22	11	4	5	2
Violaceae	..	5	21	25	21	30	14
Datiscaceae	..	..	..	1	..	..	..
Thymelaeaceae	1	6	8	11	5	4	2
Elaeagnaceae	1	2	..	..	..	..	..
Lythraceae	..	10	6	1	..	..	..
Punicaceae	..	1	1	..	..	..	..
Myrtaceae	..	1	1	..	..	..	..
Oenotheraceae	..	8	13	14	9	9	..
Hippuridaceae	..	3	3	2	..	..	..
Cynomoriaceae	..	..	..	..	..	..	..
Araliaceae	..	..	2	1	..	..	..
Umbelliferae	17	132	196	144	59	62	18
Cornaceae	..	3	3	2	..	..	..
Pirolaceae	..	..	1	7	7	7	..
Ericaceae	..	7	9	4	4	9	6
Primulaceae	2	16	30	24	14	15	7
Plumbaginaceae	23	9	15	9	3	3	3
Ebenaceae	..	1	1	..	..	..	..
Styracaceae	..	1	1	1	..	..	..
Oleaceae	..	11	15	7	..	..	..
Gentianaceae	3	12	19	16	14	16	11
Apocynaceae	..	5	5	2	..	..	..
Asclepiadaceae	1	7	10	5	3	2	..
Convolvulaceae	6	18	22	10	2	1	1
Polemoniaceae	..	..	..	1	..	..	..
Borraginaceae	20	68	101	64	25	13	6
Verbenaceae	1	5	4	1	1	1	..
Labiatae	3	166	248	176	67	66	22
Solanaceae	1	14	10	6	..	..	..
Scrophulariaceae	9	99	175	144	69	75	34
Orobanchaceae	1	26	33	9	4	2	..
Gesneriaceae	..	..	4	2	1	1	..
Lentibulariaceae	..	4	4	3	4	5	3
Globulariaceae	..	2	4	2	2	1	1
Acanthaceae	..	2	3	1	..	..	..
Plantaginaceae	7	11	11	7	4	5	5
Rubiaceae	3	52	71	58	22	26	8
Caprifoliaceae	..	7	11	13	5	..	..

THE ALTITUDINAL DISTRIBUTION OF THE SPECIES IN EACH FAMILY (*continued*)

	1. *Coastal Belt*	2. *Lowland Area*	3. *Hill and Foothill Areas*	4. *Montane Area*	5a. *Lower High Mountain Area*	5b. *Middle High Mountain Area*	5c. *Upper High Mountain Area*
Adoxaceae	..	..	1	1	..	..	..
Valerianaceae	..	21	21	17	8	8	4
Dipsacaceae	1	24	41	39	26	18	7
Cucurbitaceae	1	4	4	1	..	..	..
Campanulaceae	3	31	75	74	43	34	16
Compositae	48	337	516	378	186	179	72
Totals							
Gymnospermae	..	8	6	6	13	3	..
Monocotyledoneae	83	538	635	472	204	164	57
Dicotyledoneae	296	2115	3215	2325	1089	1026	472
Totals	379	2661	3856	2803	1306	1193	529

many species can only spread along zones which for considerable distances are limited by contours. The coastal species spread, for the most part, only along the coasts, as is well exemplified by the *Chenopodiaceae* of the Black Sea coast of our area as detailed in Chapter VIII. Here a controlling factor is the salinity of the substratum or the general edaphic nature of the coastal belt. The lowland areas have usually rich alluvial soils, are warm and sheltered, and are more highly cultivated than any other parts. The relatively primitive agricultural practices—especially that of long fallowing, allow a rich weed flora to develop and permit many otherwise typical hill plants to persist. The spring flora is especially developed in this zone and the next. The hill zone occupies a greater area in the Balkan Peninsula than any other, and this largely accounts for its richness in species, though it must be remembered that forest destruction has permitted the spread of herbaceous and shrubby species into the hill zone and their further evolution there by fractionization and crossing. The montane area is rich in woodland species whose distribution is becoming more and more restricted by man's activities, and the very varied physical features which occur especially in this and the next zone, such as outcrops of rocks, steep-sided gorges, &c., provide natural habitats for

other than woodland plants. Moreover, high mountain plants occasionally extend downwards into the montane zone, especially along gorges. The lowest high mountain zone might almost equally well be considered as a division of the montane zone since it is not always easy to separate them. While it is the richest zone in Gymosperms it is decidedly poorer than the montane zone in the other groups. The coniferous woods are not suitable habitats for the majority of flowering plants and many of the 1,306 species recorded from this zone are either inhabitants of ravines or of rocks. The middle and highest high mountain zones have a flora with a high percentage of endemics, many of which have a very restricted range. These and the Alpine, Carpathian, and Caucasian connexions are considered in Chapters XV and XVI.

While it is true that a Central European type of vegetation comes farther south in the mountains of the Pindus and Rodope than it would if the country were entirely plain or hill-land, even in these the flora has a rich endemic element, and Mediterranean and eastern types are represented. To the south of these mountains the Central European flora is lacking, even in the high mountain zones, or at most occupies a very subordinate position. On the other hand the Mediterranean flora frequently pushes northwards—along the western coast even to southern Istria—and inland up many river valleys as the Vardar, Narenta, and Maritsa.

A systematic and distributional study of the endemics—especially those of the high mountain zones of the southern districts—shows that an altitudinal migration of species has had an important influence on the taxonomic constitution of the flora. Thus in Greece there are, within various genera, many small groups of two or three or more morphologically closely allied species, of which one at least is endemic to a limited area within the district. Very frequently the species composing such a group occur at different altitudes, and the evidence is clear that the altitude, by modifying the complex of environmental factors, has been one cause of their origin as distinct species. There is no experimental evidence that the modified environment has directly caused genetical differences, but it is very probable that some of the accepted species could be shown by suitable experiments to be merely habitat forms (ecads) with only fluctuating differential characters. On the other hand the modified environments of higher altitudes would select favourable variations of mutational, hybrid, or other origin, and thus aid in the formation of a new taxonomic entity, which with increasing isolation would become a new species.

VIII

PLANT COMMUNITIES

A BROAD outline of the synecology of the Balkan Peninsula with special reference to its bearing on the phytogeography of the area is all that is attempted here. No classification of plant communities satisfactory for my immediate purpose was found, and I have therefore gradually evolved one which is purely empirical and has, no doubt, many theoretical defects.

SYNOPSIS OF THE PLANT COMMUNITIES

MARITIME COMMUNITIES.

Submerged. *Algae* and *Potamogetonaceae.*

Entirely or partly terrestrial.

Of salt-marshes: halipeda of Greece, &c.

Of sand-stretches and *sand-dunes*: open to closed types of vegetation on arenaceous terrain.

Of stony beaches: open vegetation mainly of halophytes.

Of rocky coasts: open vegetation of halophytic and xeromorphic species.

AQUATIC COMMUNITIES.

Vegetation of more or less submerged water plants.

MARSH COMMUNITIES.

Vegetation, often closed and luxuriant, of the extensive marshes of the plains and river mouths, or zoned along the margins of streams, rivers, and lakes.

BOGS AND MOORS.

Low vegetation limited to high mountain areas.

WOOD AND FOREST COMMUNITIES.

Of the Mediterranean Domain.

Aleppo pine woods with *Pinus halepensis* Mill. dominant and usually macchie for undergrowth.

Stone pine woods with *Pinus pinea* L. dominant. Nearly limited to the sea-strand.

Oak woods with *Quercus ilex* L. and *Q. aegilops* L. often dominant as trees at the lower altitudes, and *Q. conferta* Kit. and *Q. lanuginosa* Thuill. at the higher altitudes.

Laurel woods with *Laurus nobilis* L. dominant.

The montane coniferous forests with *Abies cephalonica* Loud. dominant.

Beech forests dominated by *Fagus silvatica* L.

Black pine forests with *Pinus nigra* Arn. dominant.

Of the Transitional Areas.

Manna ash-oak woods dominated by *Fraxinus ornus* L., *Quercus lanuginosa* Thuill., *Q. conferta* Kit., and *Q. sessiliflora* Salisb.

Macedonian oak woods with *Q. macedonica* DC. dominant.

Horse-chestnut woods with *Aesculus hippocastanum* L. characteristic.

The Strandja woods of mixed deciduous trees.

Rodope woods of *Juglans regia* L., *Fagus orientalis* Lipsky, and *Ostrya carpinifolia* Scop.

Of the Central European Domain.

Oak woods dominated by *Quercus conferta* Kit., *Q. cerris* L., *Q. robur* L., or *Q. sessiliflora* Salisb.

Sweet-chestnut woods with *Castanea sativa* Mill. characteristic.

Beech forests with *Fagus silvatica* L. dominant.

Conifer forests mixed or dominated by *Pinus nigra* Arn., *Picea omorika* Willk., *P. abies* Karst., or *Abies alba* Mill.

BRUSHWOOD COMMUNITIES.

Macchie dominated by evergreen shrubs.

Pseudomacchie of mixed evergreen and deciduous shrubs.

Phrygana of low shrubs and subshrubs and xeromorphic herbs.

Shiblyak dominated by deciduous shrubs.

High mountain brushwood, usually dominated by junipers or *Pinus montana* Mill.

GRASSLANDS.

High mountain meadows with a wealth of grasses and forbs.[1]

Steppe-like grasslands dominated by xeromorphic herbs.

THE HERBACEOUS VEGETATION OF STONY GROUND.

Usually open vegetation, more or less xeromorphic, but rich in species.

THE VEGETATION OF ROCKS.

Open vegetation, floristically rich and varied.

THE VEGETATION OF SANDY HABITATS.

Commencing as open vegetation and progressing naturally to forest.

MARITIME COMMUNITIES.

Submerged. Submerged communities of *Algae* are well developed in the Adriatic and Aegean seas. The poverty of vegetation in the Black Sea is due to the high sulphuretted hydrogen content of its waters. Since in this work we are entirely concerned with Phanerogams we have only to consider the few species of *Potamogetonaceae* which are marine in our area. These are *Cymodocea nodosa* Aschers and *Posidonia oceanica*

[1] *i.e.* herbs other than grasses.

Del. (Crete, Greece, Thessaly, Albania, South Macedonia, Athos Peninsula, Thrace, Montenegro, Dalmatia, South Croatia, Istria), *Zostera marina* L. (Crete, Greece, the Cyclades, Thessaly, South Macedonia, Thrace, Thracian Islands, North Bulgaria, the Dobruja, Hercegovina, Dalmatia, South Croatia, and Istria), and *Z. nana* Roth (Greece, Thessaly, Albania, Thrace, North Bulgaria, the Dobruja, Dalmatia, South Croatia, and Istria). These occur chiefly where the bed of the sea is sandy or pebbly, and 'sea-meadows' are extensively developed in the northern Adriatic. The species of *Zostera* usually flourish in water 1–8 m. in depth, but *Posidonia* will grow in considerably deeper water.

Entirely or partly terrestrial. The maritime communities which are not, or not entirely, submerged are less conspicuously developed than on the Atlantic seaboard of Europe. This is partly owing to the weak action of tides and currents, and partly to the topography and nature of the rocks. The slight tidal movement, the weakness of the currents, and the protected situation of much of the coast reduce the scouring effect and prevent especially the formation of extensive beaches. Thus for miles on the Adriatic, Aegean, and Black Sea coasts the terrestrial vegetation is almost lapped by the waves. Even in heavy storms I have never seen waves breaking on the shores comparable to those often witnessed on the Atlantic coasts. Moreover the absence of such strata as chalk-with-flints limits the beach-forming material very considerably. Nevertheless salt-marshes, sand-dunes, beaches, and maritime rocks do occur with their own plant communities, and it is particularly interesting to note the floristic composition as well as the distribution of these communities.

Of salt-marshes. Salt-marshes are developed in greater or less degree in various scattered areas round the coasts. The absence of marked tides has prevented the formation of pure mud marshes regularly flooded by sea-water. Nevertheless I feel bound to include under this term the *halipeda* which have been so well described by Heldreich for Greece, and also the salt and brackish sandy-mud marshes on the coasts of Istria, around the salt lake in the Gallipoli Peninsula, and around Valona. Very often these marshes are nearly or quite dried out in the summer months, or they may pass almost imperceptibly into fresh-water marshes. In the salt-marshes around Valona the following are characteristic species (Baldacci e Béguinot, 1918): *Petrosimonia crassifolia* Bunge, *Suaeda fruticosa* Forsk., *Salicornia herbacea* L., *Arthrocnemum glaucum* Unger, *Halocnemum strobilaceum* Bieb., *Atriplex portulacoides* L., *Limonium vulgare* Mill., and *Plumbago europaea* L. In the salt-marsh developed around the salt lake in the Gallipoli Peninsula (Turrill, 1924) occur: *Salicornia fruticosa* L., *Limonium virgatum* Fourr., *L. vulgare* Mill. var. *macroclada* Turrill, *Goniolimon*

collinum Boiss., *Juncus acutus* L. var. *heldreichianus* Heldr., *Polygonum maritimum* L., *Echinophora tenuifolia* L., *Centaurium spicatum* Fritsch, and *Frankenia hirsuta* L. I have studied several places on the coast of Istria where a flat shore with a mixed substratum of mud, sand, and stones has led to the local development of vegetation of a salt-marsh type with *Salicornia fruticosa* L., *S. herbacea* L., *Plantago coronopus* L., *Salsola kali* L., *S. soda* L., and *Atriplex* spp. Often the mud, sand, and stones are very mixed, due no doubt to the lack of sorting by tidal and current actions. The *halipeda* of Greece (as around Phaleron and near Marathon) are more or less marshy, generally flooded in winter, and with a substratum varying locally in salinity. In summer they mainly dry up, though some places remain swampy all the year. They are often situated behind a belt of sand-dunes and may extend for a kilometre or more inland. The flora is strikingly rich in species, partly definitely halophytic, partly merely able to stand brackish conditions. Heldreich (1878) mentions as characteristic species: *Linum maritimum* L., *Euphorbia pubescens* Vahl, *Lavatera cretica* L., *Spergularia salina* J. et C. Presl, *Frankenia hirsuta* L., *Erucaria myagroides* Hal., *Mesembryanthemum nodiflorum* L., *Eryngium creticum* Lam., *Bupleurum gracile* DC., *Ferula communis* L., *Cressa cretica* L., *Cuscuta monogyna* Vahl, *Heliotropium supinum* L., *H. dolosum* Notaris, *Echium sericeum* Vahl, *Centaurium spicatum* Fritsch, *C. tenuiflorum* Fritsch, *Cynanchum acutum* L., *Lycium europaeum* L., *Bellis annua* L., *Cephalaria transsilvanica* Schrad., *Scabiosa maritima* L., *Limonium sinuatum* Mill., *L. vulgare* Mill., *Arthrocnemum glaucum* Unger, *Atriplex halimus* L., *Beta maritima* L., *Suaeda fruticosa* Forsk., *Phragmites communis* Trin., *Urginea maritima* Baker, *Asphodelus fistulosus* L., *A. tenuifolius* Cav., *Juncus acutus* L., *Triglochin bulbosum* L., *Carex distans* L., *C. divisa* Huds., *C. hispida* Willd., *Polypogon monspeliensis* Desf., *Hordeum maritimum* With., *Trifolium radiosum* Wahlenb., *Melilotus sulcatus* Desf., *Lotus lamprocarpus* Boiss., *Alhagi graecorum* Boiss., *Tamarix hampeana* Boiss. et Heldr., *Oenanthe incrassans* Bory et Chaub., *Plantago crassifolia* Forsk., *Cardopatium corymbosum* Pers., and *Tragopogon longifolius* Heldr. et Sart. Floristically this habitat is one of the richest of any in Attica, though many of the above species are by no means limited to it.

Of sand-stretches and sand-dunes. Sand-stretches and sand-dunes are, like the salt-marshes, developed sporadically around the coast, but since they owe their origin largely to wind action and do not depend on tides they are more like those of Western Europe in substratum and vegetation. The flora is not nearly so rich in species as that of the salt-marshes and, excluding that of some of the Black Sea dunes and sand-stretches, is not so interesting taxonomically. It mainly consists

of widely distributed species, although in the Dobruja and Bulgaria various Russian and even Central Asian plants are to be found. On the Adriatic coast sand-dunes and sand-stretches are few and seldom extensive. They occur near Split (Spalato), at the mouth of the Narenta, Castelnuovo, Teodo, Budua, and on the Albanian shores, notably near Valona. Characteristic plants are: *Eryngium maritimum* L., *Glaucium flavum* Crantz., *Echinophora spinosa* L., *Apocynum venetum* L., *Thymbra spicata* L., *Ambrosia maritima* L., *Erianthus ravennae* Pal. de Beauv., *Cynodon dactylon* Pers., *Agropyrum junceum* Pal. de Beauv. and other species, *Plantago* sp., *Vitex agnus-castus* L., *Tamarix* spp. Baldacci in 1892 (bibl. 1896) observed the following species on the sandy sea-shore near Kanali in the neighbourhood of Preveza: *Medicago marina* L., *Eryngium maritimum* L., *Calystegia soldanella* R. Br., and *Polygonum maritimum* L. In the Gallipoli Peninsula sand-dunes occur at Suvla between the salt-marsh and the pebbly beach (Turrill, 1924). Characteristic plants are *Carex divisa* Huds., *Eryngium creticum* Lam.. *E. maritimum* L., *Pancratium maritimum* L., and *Marsdenia erecta* R.Br. On the sand-dunes of Attica the following are characteristic (Heldreich, 1878): *Cakile maritima* L., *Eryngium maritimum* L., *Medicago marina* L., *Euphorbia peplis* L., *Polygonum maritimum* L., *Salsola kali* L., *Cyperus kali* Murbeck, *Scirpus holoschoenus* L., *Imperata cylindrica* Pal. de Beauv., *Sporobolus arenarius* Duval-Jouve, *Agropyrum junceum* Pal. de Beauv., *Malcolmia flexuosa* S. et S., *Brassica tournefortii* Gouan, *Verbascum pinnatifidum* Vahl, *Centaurea spinosa* L., *Limonium graecum* O. Kuntze, *Emex spinosus* Campd., *Pancratium maritimum* L., and *Allium phalerum* Heldr. et Sart. Much of the Black Sea coast in the Dobruja and Bulgaria is margined by stretches of sand, sometimes flat or undulating, sometimes heaped up into dunes. The vegetation, as one would expect, is of an open character and varies with the degree of water and salt-content. On the drier more stabilized dunes between Varna and Euxinograd extensive communities of *Hippophae rhamnoides* L., *Salix purpurea* L., and *Populus alba* L., with individuals of *Colutea arborescens* L. and *Periploca graeca* L., and societies of *Phragmites communis* Trin., *Hordeum maritimum* With., *Atropis convoluta* Griseb., and *A. festuciformis* Boiss. are found. Other important species of the Black Sea strand flora are: *Elymus sabulosus* Bieb., *Juncus acutus* L., *J. maritimus* Lam., *Salicornia herbacea* L., *Agropyrum* spp., *Suaeda maritima* Dum., *Salsola kali* L., *Hordeum maritimum* With., *Artemisia maritima* L., *Cakile maritima* Scop., *Kochia prostrata* Schrad., *Glaucium flavum* Crantz., *Crambe maritima* L., *Lepidotrichum uechtritzianum* Bornm., *Spergularia* spp., *Medicago marina* L., *Eryngium maritimum* L., *Hypecoum ponticum* Vel., *Silene supina* Bieb., *S. pontica* Brandza, *Linaria euxina* Vel., *Cen-*

taurea sterilis Steven, *Aster tripolium* L., and *Pancratium maritimum* L.

Near Varna there is a fine stretch of sandy beach and in the absence of noticeable tides this tends to become stabilized by vegetation. In the background there are embryo dunes under the cliffs, while some plants, notably *Salsola kali* L., get within 10 m. of the sea. On the sand here I collected on August 10, 1926, *Elymus sabulosus* Bieb. var *depauperatus* Bornm., *Salsola kali* L., *Amarantus angustifolius* Lam. var. *graecizans* Thell., *Atriplex* spp., *Xanthium strumarium* L., and *X. italicum* Moretti. There was a heavy wind blowing at the time and much sand was being whirled about. A little farther landwards the vegetation was nearly closed and animals were even grazing on it. The sand here was dark with humus and *Echinochloa crus-galli* Pal. de Beauv. and *Onopordon tauricum* Willd. were abundant. Between Lake Djevna and the sea is a flat, sandy, and marshy plain, now partly drained, which I explored on August 12, 1926. The vegetation is very open and in the drier sandy parts consists mostly of prostrate or semi-prostrate plants of *Salsola kali* L., species of *Atriplex* and *Xanthium*, *Tournefortia sibirica* L. and *Cynodon dactylon* Pers. Ruderals, such as *Centaurea solstitialis* L., *C. calcitrapa* L., and *Datura stramonium* L. appear near the roads. In the wet places a poor salt-marsh flora was developed, with *Salicornia herbacea* L. and *Juncus maritimus* Lam. dominant, and *Scirpus maritimus* L., *Suaeda maritima* L., and *Spergularia marginata* Kit. local. Here and there the marshy areas were silting up and then gave a very quick succession to closed grassland, with grasses, thistles, *Lotus*, &c., which was being grazed by sheep and cattle. At Burgas in South Bulgaria on August 14, 1926, I examined the Black Sea shore which is here again a sandy stretch with small half stabilized dunes. The sand is very dark in colour and characteristic plants on it were: *Euphorbia peplis* L., *Elymus sabulosus* Bieb. var. *depauperatus* Bornm., *Centaurea arenaria* Bieb., *Corispermum nitidum* Kit., *Salsola kali* L. var. *glabra* Detharding, *Apocynum venetum* L., *Polygonum litorale* Link, *Cynanchum acutum* L., *Anchusa gmelinii* Ledeb., *Tribulus terrester* L., *Medicago marina* L., *Eryngium maritimum* L., *Plantago indica* L., and *Cakile maritima* Scop. Around the pools of water between the dunes were fine growths of *Juncellus pannonicus* C. B. Clarke and *Suaeda maritima* L.

A phenomenon of considerable phytogeographical interest is the number of South Russian salt-steppe and sea-coast plants which occur in the Dobruja and sometimes extend even to the Black Sea coasts of Bulgaria and Thrace. Particularly important in this connexion are the members of the *Chenopodiaceae*. From the Dobruja 40 species of this family are recorded, from North Bulgaria 31, from South Bulgaria 26,

and from Thrace 35. While not all of these are halophytes or South Russian in their distribution relative to the Balkan Peninsula, a considerable number are both. Interesting South Russian species are: *Bassia hirsuta* Aschers. (South Bulgaria, Dobruja), *B. sedoides* Aschers. (Thrace, North Bulgaria, Dobruja), *Camphorosma ovata* W. et K. (Thrace, South Bulgaria, Serbia), *C. ruthenica* Bieb. (South Bulgaria), *Corispermum canescens* Kit. (South Bulgaria, Dobruja), *C nitidum* Kit. (Thrace, South Bulgaria, Dobruja, Serbia), *C. filifolium* C. A. Mey. (Thrace), *C. orientale* Lam. (South Bulgaria), *Kochia laniflora* Borb. (Thrace, North Bulgaria, Dobruja, Serbia), *Eurotia ceratoides* C. A. Mey. (Dobruja), *Petrosimonia triandra* Simonk. (Dobruja), and *Suaeda heterophylla* Bunge (South Bulgaria). A number of other species have a wider and often a known discontinuous distribution around the coasts of the Balkan Peninsula. These include: *Arthrocnemum glaucum* Unger (Crete, Greece, Cyclades, Corfu, Albania, Thrace, Dobruja, Dalmatia, Istria), *Halocnemum strobilaceum* Bieb. (Corfu, Albania, South Macedonia, Thrace, Dobruja), *Petrosimonia brachiata* Bunge (Greece, South Macedonia, Thrace, South Bulgaria), *P. crassifolia* Bunge (Albania, Thrace, Dobruja), *Suaeda altissima* L. (Thessaly, South Macedonia, South Bulgaria, Dobruja), and *Suaeda splendens* Gren. et Godr. (Greece, Cyclades, Thessaly, Albania, South Macedonia, Thrace, Dobruja). Davidoff (1912) gives lists of plants limited to either the trans- or the cis-balkanic shores of the Black Sea in Bulgaria. I have had to modify his lists somewhat owing to later discoveries. To the north of the Balkan chain occur: *Mollugo cerviana* Seringe, *Spergularia salina* J. et C. Presl, *Astrodaucus bessarabicus* Drude, *Centaurea sterilis* Steven (*C. euxina* Vel.), *Jasione heldreichii* Boiss. et Orph. var. *microcephala* Vel., *Agropyrum repens* Pal. de Beauv. var. *littorale* (Host) and *Agrostis stolonifera* L. var. *gigantea* (Roth). To the south: *Alyssum minutum* Schlecht. var. *ponticum* Vel., *Marsdenia erecta* R. Br., *Beta maritima* L., *Corispermum nitidum* Kit., *C. orientale* Lam., *Atriplex portulacoides* L., *A. pedunculatum* L., *Suaeda heterophylla* Bunge, *Petrosimonia brachiata* Bunge, *Pancratium maritimum* L., *Cyperus kali* Murbeck, *Ammophila arenaria* Link. Local societies are dominant: of *Centaurea arenaria* Bieb. on the dunes of Atanasse, *Calystegia soldanella* R. Br. on those of Kalfa. On those of Lessitza *Jurinea albicaulis* Bunge is characteristic, on those of Diavolky *Peucedanum arenarium* W. et K., on those of Gheren *Erianthus ravennae* Pal. de Beauv., on those of Atia *Corispermum nitidum* Kit., and on those of Kavatzite *Ammophila* and *Pancratium.*

Of stony beaches. Stony beaches are frequent but often narrow, and, so far as I have observed on the Adriatic and Aegean coasts, not composed of large masses of well-rounded pebbles like the English shingle

beaches, but of mixtures of angular and rounded stones of various sizes, often with some mud or sand and evidently formed practically *in situ*. The great weakness of the tides and currents is emphasized in all aspects of the shore line. On the pebbly beaches of the Gallipoli Peninsula (Turrill, 1924) occur: *Eryngium creticum* Lam., *E. maritimum* L., *Matthiola tricuspidata* R. Br., *Cakile maritima* Scop., *Salicornia fruticosa* L., and *Salsola kali* L. On the Lapad Peninsula near Gruž (Gravosa) I examined some stony beaches in August 1925. The following are characteristic plants: *Limonium vulgare* L., *Salicornia herbacea* L., *Suaeda maritima* Dum., *Salsola soda* L., and *Euphorbia paralias* L. On the narrow beach south of Parenzo in western Istria in August 1922 amongst the stones and boulders I particularly noticed *Limonium cancellatum* Maire et Petitmengin, *L. vulgare* Mill., var. *macrocladum* Turrill, *Crithmum maritimum* L., *Inula crithmoides* L., and *Salicornia fruticosa* L. Other species recorded as occurring on stony and boulder-strewn stretches on the Adriatic shores are: *Arthrocnemum glaucum* Unger, *Camphorosma monspeliaca* L., *Carex extensa* Good., *Artemisia caerulescens* L., *Polygonum aviculare* L., and *Atriplex pedunculatum* L.

Of rocky coasts. Rocky coasts with a more or less halophytic vegetation occur along the Adriatic and Aegean coasts in scattered localities where harder rocks form the shore-line. The flora is often a mixture of halophytic and xeromorphic species amongst which may be mentioned: *Crithmum maritimum* L., *Lotus cytisoides* L., *Limonium cancellatum* Maire et Petitmengin, *Limonium cosyrense* O. Kuntze, *Inula crithmoides* L., *I. viscosa* L., *Euphorbia paralias* L., *Capparis rupestris* S. et S., *C. sicula* Duhamel, and *Ephedra campylopoda* C. A. Mey.

AQUATIC COMMUNITIES.

These are floristically and ecologically more uniform throughout the Balkan Peninsula than any other group of communities. The division into Mediterranean and Central European domains is less clearly indicated for the aquatic communities than for woods, brushwoods, grasslands, high mountain vegetation, &c. Relatively few Balkan Peninsular types and endemics occur in them, and the species found are mostly such as are distributed in similar habitats throughout a great part of Europe. Although many of the species have a wide distribution in our area this sometimes appears to be discontinuous, and although the available records are certainly incomplete both herbarium and field studies give the impression that the aquatic and marsh floras are less extensively developed than they have been in the geologically recent past. In such diverse areas as the Dragoman marsh in western Bulgaria and the Struma plain in South Macedonia I was impressed by

the obvious signs of silting up of lakes, the increase of solid ground, of reduction in the marsh and aquatic vegetation, and the gain of rich cultivable ground. The history of several species, so far as it can be traced from old records and present distribution, suggests the same widely spread succession. The scattered localities for *Trapa natans* L. and *Hottonia palustris* L. are illustrations.

The aquatic flora of most parts of Crete and Greece is very poorly developed. This is mainly due to the scarcity of permanent lakes, ponds, and rivers of freshwater. While these may be present after the winter rains, they are more often than not dry during the summer months. Vierhapper (1916) mentions the following as found by him in Crete: *Ruppia maritima* L. var. *rostrata* Agardh (*R. rostellata* Koch), *Potamogeton nodosus* Poir. (*fluitans* Roth p.p.), and *Zanichellia palustris* L. Heldreich (1878) lists the following species as characteristic for Attica: *Ranunculus aquatilis* L., *Callitriche verna* L., *Typha angustifolia* L., *Potamogeton natans* L., *Alisma plantago* L., *Scirpus tabernaemontani* C. C. Gmel., and *S. maritimus* L. Relatively to Crete and Greece the aquatic flora of Macedonia is well developed. The following species are characteristic (see especially Petkoff 1910): *Ranunculus aquatilis* L., *Nymphaea alba* L., *Nuphar luteum* L., *Aldrovanda vesiculosa* L., *Trapa natans* L., *Myriophyllum verticillatum* L., *M. spicatum* L., *Callitriche verna* L., *Ceratophyllum submersum* L., *C. demersum* L., *Limnanthemum nymphaeoides* Hoffm. et Link, *Hydrocharis morsus-ranae* L., *Vallisneria spiralis* L., *Stratiotes aloides* L., *Potamogeton natans* L., *P. lucens* L., *P. crispus* L., *P. perfoliatus* L., *P. pusillus* L., *Zannichellia palustris* L., *Lemna trisulca* L., *L. minor* L., *L. gibba* L., and *L. polyrrhiza* L. Stefanoff (1921) records the following aquatics as occurring in western Thrace: *Potamogeton nodosus* Poir., *P. pusillus* L., *Lemna minor* L., *Spirodela polyrrhiza* Schleid., *Ranunculus trichophyllus* Chaix, *Nymphaea alba* DC., *Nuphar luteum* Sm., *Ceratophyllum* sp., and *Trapa natans* L.

In the central and northern districts of the Balkan Peninsula the aquatic communities are only of importance in the lowlands and especially in the river valleys. Apart from the larger rivers and the few lakes, the scattered pools and small streams have a poor vegetation and flora of real aquatics, and most of the species are of wide general distribution. The following are more or less frequent: *Zannichellia palustris* L., *Lemna minor* L., *L. trisulca* L., *L. gibba* L., *Wolffia arrhiza* Wimm., *Hydrocharis morsus-ranae* L., *Ceratophyllum demersum* L., *C. submersum* L., *Utricularia vulgaris* L., *Stratiotes aloides* L., *Myriophyllum spicatum* L., *Hottonia palustris* L. (scattered), *Potamogeton natans* L., *P. nodosus* Poir., *P. crispus* L., *P. lucens* L., and other species, *Sagittaria sagittifolia* L., *Polygonum amphibium* L., *Callitriche palustris* L., *Nymphaea alba* L., *Nuphar luteum* Sm., *Trapa natans* L., and *Limnan-*

themum nymphaeoides Hoffm. et Link, *Ranunculus fluitans* L., and *R. trichophyllus* Chaix. In or near the Serbian Danube occur: *Naias minor* L., *N. marina* L., and *Aldrovanda vesiculosa* L. The countries on the eastern shore of the Adriatic have a very similar freshwater aquatic flora, with the genus *Potamogeton* well represented.

MARSH COMMUNITIES.

While better developed than the true aquatic vegetation in many parts of the Balkan Peninsula the marsh vegetation is still not strikingly different from that of Europe generally. Though a few Balkan Peninsular and endemic species occur, the mass of the vegetation is composed of species with a wide general distribution and there is no great difference between that of the Mediterranean and Central European domains in our area. The marsh vegetation is chiefly found in the plains and lowlands and often brackish-water and freshwater formations merge into each other. The rivers are more often fringed with brushwood than with marsh herbs except in the large plains, but many of the lakes and the river mouths and deltas have extensive areas of marsh, most of which have a luxuriant herbaceous vegetation.

In Greece and Crete the watercourses and river beds are frequently lined with *Nerium oleander* L., *Vitex agnus-castus* L., *Tamarix* spp., *Arundo donax* L., *Phragmites communis* Trin., and *Erianthus ravennae* Pal. de Beauv. The plane, white willow, and white poplar may also occur. Vierhapper (1916) records for marshy places in Crete: *Ranunculus sardous* Crantz, *R. muricatus* L., *Nasturtium officinale* R. Br., *Hypericum perfoliatum* L., *Trifolium resupinatum* L., *T. nigrescens* Viv., *Lythrum flexuosum* Lag., *Apium nodiflorum* Reichb. f., *Blackstonia perfoliata* Huds., *Veronica anagallis* L., *Samolus valerandi* L., *Polygonum serrulatum* Lag., *Alisma plantago* L., *Juncus maritimus* Lam., *J. bufonius* L., *Cyperus badius* Desf., *Scirpus holoschoenus* L., *S. maritimus* L., *Carex divisa* Huds., *Polypogon monspeliensis* Desf., and *Arundo plinii* Turra. *Typha angustifolia* L., *Alisma plantago* L., *Scirpus tabernaemontani* C.C. Gmel., and *S. maritimus* L. are typical plants of the few wet places of the Attic plain. In the Struma Plain of South Macedonia I studied a rich marsh vegetation. *Phalaris arundinacea* L., *Iris pseudacorus* L., *Heleocharis palustris* R. Br., *Orchis palustris* Jacq., *Lythrum salicaria* L., *Scirpus maritimus* L., *Scirpus holoschoenus* L., *Cyperus longus* L., and *Juncus bufonius* L. were characteristic, and trees of *Salix alba* L. overhung the banks of the river in places. *Tamarix tetrandra* Pall. was common in wettish places on the Plain. *Gratiola officinalis* L., *Veronica anagallis* L., *Lycopus europaeus* L., and *L. exaltatus* L. f. are also common marsh plants of the area. In the Maritsa basin of South Bulgaria there are extensive marshes, some of which have been turned into rice-fields.

Distinctive plants of this neighbourhood are: *Phragmites communis* Trin., *Scirpus lacustris* L., *Typha latifolia* L., *T. laxmannii* Lepech., *Carex* spp., and *Cyperus* spp.

Along the course of the River Ilyina in the Rila mountains there are extensive stretches of marshy ground. *Alnus incana* Moench forms brushwood, but in many places *Petasites albus* Gaertn. is the dominant plant, associated with *Caltha palustris* L., *Filipendula ulmaria* Maxim., and *Orchis latifolia* L., The *Petasites* has a *Gunnera*-like appearance with huge leaves more than a metre in diameter. Damp meadow plants are abundant a short distance from the main stream.

In the north-western parts of our area marshes are almost entirely limited to the river mouths and elongated valleys or poljes in the karst regions. According to Petraschek (1895) in Bosnia and Hercegovina there are forty-nine poljes with an area of 157,720 hectares, of which about 56,000 are periodically inundated and about 19,000 are swampy. These poljes are at various altitudes from 300 to 1,200 m. and their vegetation is sometimes predominantly Mediterranean (as in the Popovo polje near Trebinje), sometimes with only a few Mediterranean species (as in the Mostarsko blato near Mostar). In Dalmatia also the river mouths and poljes usually have a luxuriant marsh vegetation and associated Mediterranean plants. Characteristic vegetation consists of: *Scirpus lacustris* L., *S. maritimus* L., *Heleocharis palustris* R. Br., *Cladium mariscus* R. Br., *Typha* spp., *Cyperus* spp., *Leucojum aestivum* L., *Iris pseudacorus* L., *Butomus umbellatus* L., *Phragmites communis* Trin., *Arundo donax* L., *Carex* spp., *Sparganium erectum* L., *Euphorbia palustris* L., *Lythrum* spp. *Mentha* spp., *Veronica* spp., *Lycopus* spp., *Vitex agnus-castus* L., and *Salix alba* L. In central Albania communities of *Cynara cardunculus* L. are conspicuous in the extensive marshes. In Bosnia the most characteristic marsh plants are: *Phragmites communis* Trin., *Glyceria plicata* Fries, *Carex* spp., *Heleocharis palustris* R. Br., *Cladium mariscus* R. Br., *Typha angustifolia* L., *T. latifolia* L., *Sparganium erectum* L., *Alisma plantago* L., *Butomus umbellatus* L., *Leucojum aestivum* L., *Iris pseudacorus* L., *Caltha palustris* L., *Lythrum salicaria* L., *Epilobium hirsutum* L., *Lycopus* spp., *Veronica* spp. In the Dragoman marsh (720 m.) occur: *Typha* spp., *Phragmites communis* Trin., *Alisma plantago* L., *Ranunculus lingua* L., *Sparganium simplex* Huds., *Caldesia parnassifolia* Parl., and *Iris pseudacorus* L.

In the northern parts of our area it is especially along the Danube and its main tributaries (Sava, Morava, &c.) that the marsh vegetation is luxuriantly developed. Here there are many square miles of swamp almost dried up in summer and covered with a lush vegetation, and flooded in the winter and spring. Dominant elements are: *Phragmites*

communis Trin., and species of *Typha*, *Carex*, *Cyperus*, *Juncus*, *Oenanthe*, *Scirpus*, and *Glyceria*. Many other species occur in societies or scattered. These include: *Alisma plantago* L., *Butomus umbellatus* L., *Caltha palustris* L., *Heleocharis palustris* R. Br., and species of *Ranunculus*, *Sparganium*, *Rumex*, *Mentha*, *Epilobium*, *Lycopus*, *Lythrum*, and *Polygonum*. The vegetation of the mouths of the Danube has been adequately dealt with by Miss Pallis (1916). The dominant marsh plant is *Phragmites communis* Trin. *β flavescens* Gren. et Godr. and masses of floating fen (plav) are characteristic, consisting of almost vertical reed-rhizomes and retained soil. Lists of plav, salt-marsh, and aquatic plants are given by her. The forests fringing the watercourses consist almost entirely of *Salix alba* L. Horses and cattle being turned out to graze when the water is low destroy all the seedlings they can reach. However, young trees in the water often escape and aid the formation of land. The animals also have a selective effect on the herbaceous vegetation, the most numerous remaining plants being the unpalatable ones, such as *Althaea officinalis* L., *Lythrum salicaria* L., *Bidens tripartita* L., *Xanthium spinosum* L., *Myosotis palustris* Roth, *Symphytum officinale* L., *Calystegia sepium* R. Br., *Mentha aquatica* L., *Urtica dioica* L., *Euphorbia salicifolia* Host, and coarse, hairy grasses.

In the high mountain altitudinal zones there is frequently no well-marked division between marsh and bog vegetation. When definite streams are formed these often have a rapid flow and cut a gorge-like bed, with more or less steep sides and frequent waterfalls, allowing little room for the growth of marsh plants. On the plateaux the water may be held up in small pools but its aeration is usually slight and the reaction acid, the vegetation being of a bog and not of a marsh nature. The altitude of the high mountain lakes of the Rila is too great for the development of ordinary aquatic or marsh vegetation. On the Vitoša I have seen in the second high mountain zone ('subalpine' of many authors) patches of vegetation consisting largely of marsh plants, but it is necessary to emphasize that wet 'subalpine' meadows, peaty bogs, small marshes, and wet stony habitats alternate, and merge and change according to quite local and even temporary conditions. The following marsh plants of the Vitoša may be mentioned: *Caltha palustris* L., *Gentiana bulgarica* Vel., *Geum coccineum* S. et S. *Primula farinosa* L. var. *exigua* Vel., *Cardamine amara* L., *Parnassia palustris* L., *Angelica pancicii* Vandas, *Cirsium appendiculatum* Griseb., and *Filipendula ulmaria* Maxim.

BOGS AND MOORS.

Moors comparable to those of north-western Europe are practically non-existent in the Balkan Peninsula so far as I know. On the other

hand, a considerable total area of often patchy, boggy ground occurs in the high mountain altitudinal zones and is best classified under this general heading. Many of the species have a wide general distribution occurring in similar habitats in many parts of Europe or of the Northern Hemisphere generally. Unfortunately my own observations of this type of vegetation have only been made in the centre of the Balkan Peninsula, and I have found no records of it for Greece and Crete.

On the Vitoša from about 1,750 m. up to just below the highest peak (2,285 m.) there is much ground of a boggy nature passing imperceptibly into wet high mountain meadow partially drained by small streams. The Vitoša forms an important watershed between the Black Sea (Danube) and Aegean (Struma) rivers, and the numerous small streams on the high plateau seem at times undecided which way to flow. It follows that the accumulated water frequently collects as small, still pools, with species of *Sphagnum* and other bog plants forming a layer of peat. Moreover the water, even where it drains over bare rocks, retains any acidity derived from the decaying vegetation, since the rocks here are of an acid igneous and metamorphic nature. Characteristic bog plants include: *Vaccinium uliginosum* L., *Arctostaphylos uva-ursi* Spreng., *Eriophorum angustifolium* Roth, *E. vaginatum* L., *E. latifolium* Hoppe, *E. gracile* Koch, *Parnassia palustris* L., *Orchis latifolia* L., *O. globosa* L., *O. ustulata* L., *Crocus veluchensis* Herb., *Drosera rotundifolia* L., *Pinguicula vulgaris* L., and *Soldanella alpina* L. Sometimes the wet ground is not peaty but stony, and *Ranunculus platanifolius* L., *Aconitum vulparia* Reichb. var. *ranunculifolium* Reichb., and *Gymnadenia frivaldii* Hampe occur. In the pools at the sources of the Struma we found *Utricularia minor* L. When the ground is somewhat better drained the vegetation is more like that of a moor, but such a type of terrain is seldom extensively developed. *Bruckenthalia spiculifolia* Reichb. replaces the *Calluna vulgaris* L. of north-western Europe and *Molinia caerulea* L., *Carex lachenalii* Schkuhr, *C. canescens* L., *C. flava* L., *C. limosa* L., *Eriophorum angustifolium* Roth, *E. latifolium* Hoppe, *Nardus stricta* L., *Salix lapponum* L., *Pyrola rotundifolia* L., *Vaccinium myrtillus* L., *V. vitis-idaea* L. are frequent.

Iwanow and Drenowsky (1912) record a 'high-moor formation' for the Kalofer Balkan with *Pinguicula leptoceras* Reichb., *P. vulgaris* L., and *Soldanella montana* Willd., at 1,900–2,200 m. In wet stony places *Cortusa matthioli* L. var. *pubens* Schott, *Saxifraga stellaris* L., *Viola biflora* L., and *Primula frondosa* Janka occur. Extensive bog and moorland vegetation occupies much of the high mountain Vlasina plateau in Serbia. It has been very fully investigated floristically by Košanin (1910), who records: *Molinia caerulea* Moench, *Nardus stricta*

L., *Eriophorum angustifolium* Roth, *E. latifolium* Hoppe., seventeen species of *Carex*, several species of *Juncus*, *Crocus veluchensis* Herb., several orchids, *Drosera rotundifolia* L., *Parnassia palustris* L., *Pyrola minor* L., *Pinguicula vulgaris* L., *Utricularia vulgaris* L., *U. bremii* Heer, *Vaccinium myrtillus* L., and *Bruckenthalia spiculifolia* Reichb. In July 1926 I saw the rare endemic *Primula deorum* Vel. growing in a stony bog at the base of the final peak of Musala. Here species of *Carex*, *Pinguicula*, and *Saxifraga* were growing with 'the primrose of the gods' in a shallow bog of *Sphagnum*.

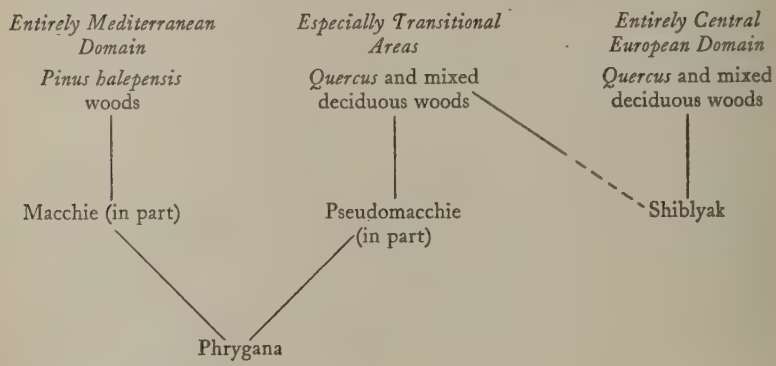
WOOD AND FOREST COMMUNITIES.

General. In Chapter X, on the influence of man on the flora and vegetation, evidence has been accumulated which proves that forest destruction has been a widespread phenomenon in the Balkan Peninsula. Indeed few large forests remain in the lower altitudinal zones and even many of the montane and high mountain forests have suffered, and are suffering, very considerably from human interference. Thus other types of vegetation now occur where formerly high forest existed, and these are not necessarily initial stages for a fresh succession with a climax in forest of a type similar to that previously destroyed. Indeed natural rejuvenation of a lumbered forest is not commonly permitted in the Balkan Peninsula. It follows that the primitive types of forest are becoming more and more restricted and that it is necessary to visit relatively inaccessible areas to study them.

Apart from the destructive effects of man's activities, climate is the most important factor in the distribution of the different species and communities of trees in our area. The edaphic factor is of secondary importance except in the north-east. Climate is here given a wide meaning, but its most general importance for the ecology of the Balkan Peninsula is the seasonal relationship between maximum rainfall and maximum temperature and between minimum rainfall and minimum temperature. This, as we have seen, leads to two main zones of climate, with various intermediate sub-zones and modifications due to altitude and orientation. Broadly speaking, the Mediterranean climatic zone is characterized by the hot and dry seasons coinciding. Thus when temperature conditions most favour vegetative and floral activity the water supply is a limiting factor, and, for many species, midsummer is at least as much a resting period as midwinter. Within the typical Mediterranean domain aestivation is therefore at least as conspicuous a feature of the flora as hibernation. In the Central European climatic zone, on the contrary, the rainfall is fairly equally spread throughout the year or even reaches a maximum in early summer. Winter is here a definite and the only resting period for many perennial plants. We are not for the

moment concerned with the morphological adaptations whereby individual species succeed under conditions adverse to the flora as a whole, and we can also ignore accidental and extremely local habitat conditions which may counterbalance the general factor of climate. In the plant communities hitherto enumerated in this chapter climate has only a secondary influence. If the sea is not near maritime communities do not occur, if abundant water is absent aquatic, marsh, and bog communities do not exist, but given the sea or the non-saline water the same type of vegetation occurs within wider limits of temperature, rainfall, and general climate than on land. But with the forests and other plant communities dealt with later the influence of climate is supreme and we have to distinguish between those of the Mediterranean and those of the Central European domain, within the Balkan Peninsula. Since there is no sharp line of demarcation it is also necessary to consider separately certain transitional areas.

Diagram to illustrate the relationships between the most important woody communities of the lowland and hill altitudinal zones.



A. **Of the Mediterranean Domain.**

The dominant tree vegetation is evergreen, either coniferous or broad-leaved. The woods are relatively more open than in the Central European domain and the undergrowth flora often richer in species if not in individuals. The true forest in the Mediterranean domain of the Balkan Peninsula is nearing the southern limit of its range, since it does not extend into the desert region of North Africa, and partly for this reason reforestation and natural rejuvenation are both rarer, more difficult, and take a longer time than in the Central European domain. An account of the chief communities follows.

Aleppo pine woods. Pinus halepensis Mill. is the chief high forest tree

of the coastal lowlands in the Mediterranean domain of our area and in places attains to 1,000 m. altitude. Thick Aleppo pine consociations without macchia or phrygana undergrowth are rare but are to be found on the west coast of Greece. Consociations of *P. halepensis* (and its var. *brutia*) occur naturally in southern Dalmatia, south of Spljet (Spalato), and at intervals to Greece, in Crete, on the Aegean islands, in the Athos and Khalkidikē Peninsulas, and in Thrace. In August 1925, I made a careful study of the Aleppo pine-woods on the Lapad Peninsula, near Gruž (Gravosa), and on the southern part of the isle of Lacroma, near Dubrovnik (Ragusa). In both places the pine woods were well developed and formed a wonderful contrast with the almost bare hill-slopes of Mt. Sergi which I climbed during the same week and which must have been similarly forest clad at one time. Some of the trees were more than 25 m. in height and had trunks up to 1 m. in diameter. The shrub undergrowth on Lapad consisted chiefly of: *Juniperus phoenicea* L., *J. oxycedrus* L., *Pistacia lentiscus* L., *Calycotome infesta* Guss., *Myrtus communis* L., *Erica verticillata* Forsk., *E. arborea* L., and *Phillyrea media* L. On Lacroma this layer society was composed of *Arbutus unedo* L., *Juniperus oxycedrus* L., *J. phoenicea* L., *Myrtus communis* L., *Pistacia lentiscus* L., *Coronilla emeroides* Boiss. et Sprun., *Phillyrea media* L., *Erica arborea* L., *E. verticillata* Forsk., *Ruscus aculeatus* L., here and there a small tree of *Ceratonia siliqua* L., and a little *Calycotome infesta* Guss., *Quercus ilex* L., and wild olives.

Stone pine woods. *Pinus pinea* L. has a much more limited distribution in the Balkan Peninsula than the last species. Its natural area has probably been much reduced by deforestation but it appears to have always been of secondary importance. Except as a cultivated tree it is limited to Crete, Greece, the Cyclades, Corfu, Athos Peninsula, and Thrace. It may occur in small pure groups or associated with *P. halepensis* Mill. It is most important in the western Peloponnese, where it is, now at least, almost limited to the sea-strand.

Oak woods. The oaks of the Mediterranean domain in the Balkan Peninsula are the most important forest trees with broad leaves. Both *Quercus coccifera* L. and *Q. ilex* L. are evergreen species of wide distribution and occur either as shrubs or as trees. They rarely form extensive societies as trees except in Crete and the Peloponnese but are frequent in all kinds of high forest and brushwood associations in the lower and hill zones. The deciduous but coriaceous *Q. aegilops* L. is limited to Crete, Greece, the Cyclades, Epirus, Albania, Thrace, and Montenegro. It sometimes forms important woods from the lowland to the montane zones (rarely in the last). Collecting its cups and acorns for tanning material is an important industry in Greece and the Cyclades. The woods are generally open and are often used as grazing

grounds. Occasionally groups of *Q. conferta* Kit. and *Q. lanuginosa* Thuill. are mixed with the Valona oak (*Q. aegilops* L.). In the western Peloponnese evergreen oak woods pass into deciduous oak woods above about 5–700 m. altitude. *Q. conferta* Kit. and *Q. lanuginosa* Thuill. are the dominant species. In Kapellis in Elis a large area between 500 and 800 m. in altitude is covered with woods dominated by *Q. conferta*. This species is one of the most widespread of the oaks in the Balkan Peninsula and is by no means limited to the Mediterranean domain. I have examined woods of it in South Macedonia (Krusa Balkan) and in Serbia (Suva Planina, &c). The former district is essentially Mediterranean, though not typically so, and the oak woods are more open than in the Central European domain, having a tendency to degenerate into pseudomacchie. *Q. lanuginosa* Thuill. is recorded for all the major and most of the minor divisions of the Balkan Peninsula, and is often abundant. In the Mediterranean domain it occurs most frequently in the hill and montane zones in mixed or fairly pure communities. Frequent associates of the oaks in the hill and montane zones of Epirus and Thessaly are: *Cercis siliquastrum* L., *Phillyrea* spp., *Carpinus orientalis* Mill., *Ostrya carpinifolia* Scop., *Fraxinus excelsior* L., *Castanea sativa* Mill., *Cornus mas* L., *Laurus nobilis* L., *Acer pseudoplatanus* L., and *Pyrus communis* L. Halácsy (1904) gives a long list of herbs occurring as undergrowth. The woods are often mixed or are dominated by oaks, but occasionally another species dominates locally. Thus fairly pure woods of *Fraxinus excelsior* L. occur. *Castanea sativa* Mill. forms woods in the Spercheus valley, in Euboea, in Arcadia, in Crete (Mt. Ida), and in the transitional areas (as on Mt. Hortiach in South Macedonia).

Laurel woods. Laurel woods dominated by *Laurus nobilis* L. occur in the Mediterranean and transitional areas of the Balkan Peninsula. The species is recorded from Crete, Greece, Thessaly, Epirus, Albania, the Athos Peninsula, Thrace, Hercegovina, Dalmatia, South Croatia, and Istria. In many parts it is scattered in macchie and in woods dominated by other species, but occasionally it forms the main constituent over fairly wide areas. I studied small societies in the neighbourhood of Gruž (Gravosa) in Dalmatia and more extensive communities on the eastern side of Istria in 1925. The following account is based on observations made between Lovrana and Abbazia, and above Volosca up towards Mattuglie. The laurel is developed sometimes as tall brushwood, sometimes as high forest. Dense bushes mixed with scattered *Carpinus orientalis* Mill., *Ostrya carpinifolia* Scop., *Fraxinus ornus* L., *Quercus lanuginosa* Thuill., *Juniperus oxycedrus* L., *Coronilla emeroides* Boiss. et Sprun., *Paliurus spina-Christi* Mill., *Prunus spinosa* L., and *Cornus sanguinea* L., cover much of the lower slopes leading to

Mt. Maggiore. The laurel bushes here are up to about 3 m. in height and are often densely placed and frequently in pure stands. In the thickest parts *Ruscus* is often the only undergrowth. Liane-like sprawling and climbing plants abound in the more open parts and include *Rubus ulmifolius* Schott, *Clematis vitalba* L., *Smilax aspera* L., *Asparagus acutifolius* L., *Tamus communis* L., and *Hedera helix* L. Smaller areas of high wood with laurel trees up to 15 m. high had only *Ruscus* and *Hedera* as undergrowth. Laurel woods with fine tall trees and *Ruscus* undergrowth were examined north-west of Volosca, and between here and Mattuglie the laurel dies out as one climbs higher, being replaced by oak woods mixed with *Carpinus*.

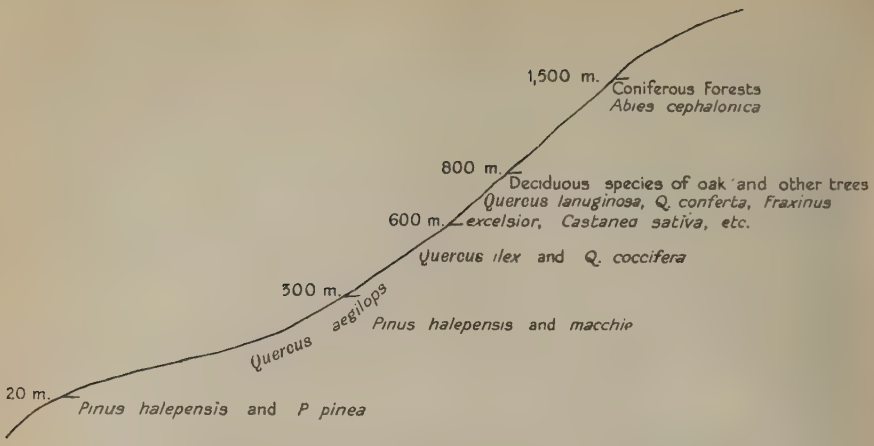
Plane woods. *Platanus orientalis* L., often mixed with species of *Populus* and *Salix*, forms communities in wet places in Crete and Greece and occasionally in South Macedonia, and in the lower parts of the Rodopes.

Cypress woods. *Cupressus sempervirens* L. (as the var. *horizontalis* Godr.) is certainly wild in Crete. Rikli (1915) records open woods in the Sphakia mountains between 300 and 750 m. altitude. These formerly had a much greater extension as was indicated by the finding of relict trees. The woods were very open, the trees occurring singly or in small groups. The undergrowth consisted predominantly of evergreen and deciduous shrubs, and thorny and tomentose small shrubs of the Cretan phrygana.

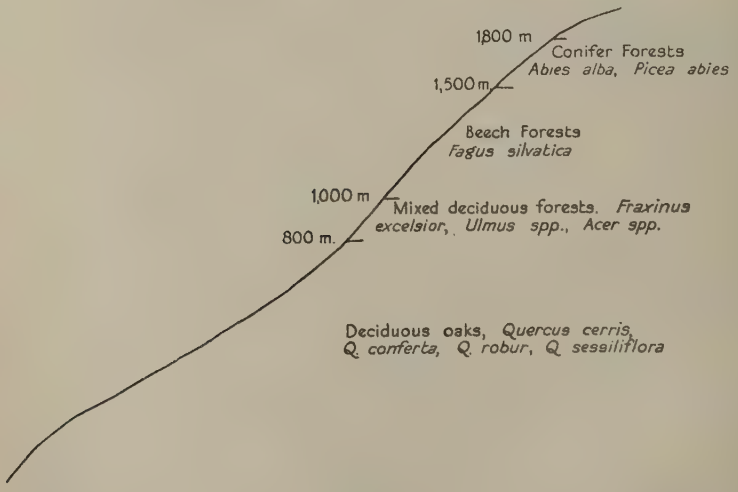
The hill and montane coniferous forests. In the south of the Balkan Peninsula these are generally composed of *Abies cephalonica* Loud. in one or another of its varieties. Nearly all of the higher mountains are surrounded by a wide belt of such woods or their remnants and the lower ones are frequently so covered to their summits, or were before man interfered. The altitudinal limits of the fir woods vary considerably for different mountains, and the underlying causes of this need investigation. Probably rainfall maxima and distribution, winds, accessibility to lumbering, and altitude of the mountain mass are all concerned. *Abies cephalonica* Loud. in one or more of its varieties is known from Greece, Thessaly, Epirus, North Macedonia (only just over the southern boundary), South Macedonia, and the Athos Peninsula.

Taxus baccata L., occurs as far south as Mt. Malevo in Laconia, but nearly always as a scattered tree in beech, fir, and mixed woods from the montane zone nearly to the tree limit.

Beech forests. The beech forest is an extension of the Central European vegetation and only occurs on the higher mountains where the climatic conditions approximate to those of Central Europe. It is noteworthy that beech forests are not found, even in the mountains, south of Thessaly, Acarnania, and Aetolia. Many of the species



Typical Tree and Forest Zonation in the Mediterranean Domain



Typical Tree and Forest Zonation in the Central European Domain

accompanying the northern Greek beech woods as undergrowth or ground flora are essentially Central European, though there is a good percentage of endemics.

Black pine forests. *Pinus nigra* Arn. has a wide distribution throughout the Balkan Peninsula. It often forms extensive woods in the lowest high mountain zone in the Mediterranean domain, occurring in Epirus, Thessaly, Aetolia, Euboea, the Peloponnese, and Crete. *P. leucodermis* Ant. accompanies *Abies cephalonica* and *P. nigra* on the Thessalian Olympus. In Dalmatia *P. nigra* frequently forms woods at much lower altitudes on the hills and mountains, in places being accompanied even by macchia undergrowth. Thus on the Sabbioncello Peninsula *Juniperus oxycedrus* L., *J. phoenicea* L., dwarfed *Quercus ilex* L., *Erica verticillata* Forsk., *E. arborea* L., *Genista sericea* Wulf, *G. dalmatica* Bartl. et Wendl., *Cotinus coggygria* Scop., *Pistacia terebinthus* L., *Myrtus communis* L., *Arbutus unedo* L., *Viburnum tinus* L., and *Phillyrea latifolia* L. form the undergrowth to black pine wood.

B. **Of the Transitional Areas.**

Many parts of the Balkan Peninsula have a climate intermediate in one respect or another between that of the typical Mediterranean and that of the typical Central European portions. In these the flora and vegetation tend to show a mixed character. My own observations and studies indicate that the vegetation (that is the communities found) is a more delicate test for the true Mediterranean climate than the flora (that is the mere occurrence of species apart from their abundance and association into types of vegetation). This is especially true for the forest and brushwood communities. Thus I consider as transitional areas those in which macchie and *Pinus halepensis* Mill. woods are absent from the lowlands, being replaced by pseudomacchie and oak or mixed woods, but where the flora is still predominantly Mediterranean, and in addition the relatively small area in south-eastern Bulgaria and eastern Thrace which is essentially Pontic-Caucasian in its vegetation (and probably also in its climate). It is possible that this last will have to be definitely accepted as a separate domain when it has been more extensively studied in eastern Thrace.

Manna ash-oak woods. Woods dominated by *Fraxinus ornus* L. and species of *Quercus* are found covering large areas in the lowland and hill zones of the western parts of the Balkan Peninsula associated with a flora often mainly Mediterranean in the general distribution of its species. The term 'karst-woods' has been applied to them by Beck and other authors, and it is a useful term for students of the vegetation of the eastern Adriatic countries, in spite of the objection that considerable variations in composition occur amongst the woods on the karst.

Frequently there is no sharp line of demarcation between karst manna ash-oak woods and karst brushwoods (pseudomacchie and shiblyak). This is largely due to the influence of man and his flocks leading to the destruction of the trees. Characteristic components of the manna ash-oak woods as I have studied them, especially in Istria, are *Fraxinus ornus* L., (locally dominant), *Quercus lanuginosa* Thuill. (locally dominant), *Q. sessiliflora* Salisb., *Q. cerris* L., *Carpinus orientalis* Mill., *C. betulus* L., *Ostrya carpinifolia* Scop., *Corylus colurna* L., *Acer monspessulanum* L., *A. campestre* L., *Celtis australis* L., *Prunus mahaleb* L., *Pyrus communis* L., *P. torminalis* Ehrh., and *P. aucuparia* Gaertn. The woods are usually light and open and the undergrowth is often rich and tends to merge into brushwood. Characteristic are: *Juniperus communis* L., *J. oxycedrus* L., *Corylus avellana* L., *Pistacia terebinthus* L., *Paliurus spina-Christi* Mill., *Cotinus coggygria* Scop., *Euonymus europaeus* L., *E. verrucosus* Scop., *Prunus spinosa* L., *Coronilla emeroides* Boiss. et Sprun., *Colutea arborescens* L., *Ligustrum vulgare* L., *Rhamnus fallax* Boiss., *R. intermedia* Steud. et Hochst., *Crataegus monogyna* Jacq., *Cornus sanguinea* L., with species of *Rubus* and *Rosa*. The ground-flora is correspondingly rich but consists mainly of plants found also in the brushwood, species limited to woodlands being relatively rare.

Macedonian oak woods. Over more limited areas and only in parts of Epirus, Albania, North and South Macedonia, Montenegro, and Hercegovina *Quercus macedonica* DC., occurs as a dominant in wood communities with *Q. lanuginosa* Thuill., *Q. sessiliflora* Salisb., *Q. cerris* L., *Carpinus orientalis* Mill., *Ostrya carpinifolia* Scop., *Fraxinus ornus* L., and *Celtis australis* L.

Horse-chestnut woods. Aesculus hippocastanum L. has a limited distribution in Epirus, Thessaly, Phthiotis, and Eurytania, where it occurs in montane woods, but rarely as a dominant. There is also a wood of this tree in North Bulgaria, near Preslav, on the northern foot of the Derven Balkan. Here it is associated with *Tilia tomentosa* Moench, *Juglans regia* L., *Acer pseudoplatanus* L., *A. campestre* L., *Carpinus betulus* L., *C. orientalis* Mill., *Fraxinus excelsior* L., and *Fagus silvatica* L. Adamović (1907–8) has investigated this wood and concludes that the *Aesculus* is certainly native. If this is so the wood must be a relict, as indeed is the species in the Balkan Peninsular flora as a whole.

The Strandja woods. The woods of the Strandja range in south-eastern Bulgaria and in eastern Thrace have only been explored botanically in the northern (Bulgarian) portion. An interesting account of them has been published by Stefanoff (1924). The topography of the hills is of the greatest significance. The deep and steeply eroded ravines with streams and small pools ensure a high degree of moisture through-

out the year and protect a mesophytic vegetation from the summer drought. The woods can be divided as follows: (1) Woods of the banks, of a type generally developed along the coasts of the Black and Aegean seas with *Populus alba* L., *P. tremula* L., *Salix fragilis* L., *S. alba* L., *S. cinerea* L., *Alnus glutinosa* Gaertn., *Quercus haas* Kotschy, *Ulmus* spp., *Acer campestre* L., *Fraxinus excelsior* L., *F. pallisae* Wilmott, *F. oxycarpa* Willd., *Periploca graeca* L., *Vitis vinifera* L., *Smilax excelsa* L., and *Ruscus aculeatus* L. (2) Subxerophilous formations of (*a*) Mediterranean and (*b*) Pontic type, the former with predominating brushwoods and forming a floristic transition to macchie, the latter mainly high forest. In both summer-green oaks are characteristic, strongly mixed in the former with *Ulmus campestris* L., *Acer tataricus* L., and *Paliurus spina-Christi* Mill. (3) Mesophilous wood formations in two facies (*a*) oriental beech, either pure *Fagus orientalis* Lipsky or mixed with *Carpinus betulus* L. and (*b*) mixed mesophilous woods. The latter are always in the deepest zones of the ravines, and here the Pontic mesophilous trees and shrubs are most strongly developed. A rich undergrowth of evergreen shrubs is composed of *Rhododendron ponticum* L., *Ilex aquifolium* L., *Prunus laurocerasus* L., and *Daphne pontica* L. Other noteworthy species are: *Acer pseudoplatanus* L., *Taxus baccata* L., *Ruscus aculeatus* L., *R. hypoglossum* L., *Carpinus betulus* L., *C. orientalis* Mill., *Fagus orientalis* Lipsky, *Epimedium pubigerum* Morr. et Dec., *Cotoneaster pyracantha* Spach, *Pyrus torminalis* Ehrh., *P. domestica* Sm., *Mespilus germanica* L., *Tilia tomentosa* Moench, *Hypericum androsaemum* L., and *Vaccinium arctostaphylos* L.

Rodope woods. A type of woodland that is difficult to place but which can be conveniently considered after the Strandja woods is the *Juglans-Ostrya-Fagus orientalis* forest which Prof. N. Stoyanoff, Mr. B. Stefanoff, and I discovered in the southern Rodopes in July 1926 between Buju and Daridere. Since we have not yet published a separate account of this and also because of its unique phytogeographical interest a fairly full description will be given. The valley came down steeply from the *Fagus silvatica* zone into that of the oaks which clothed most of the hill-sides. At 900 m. we entered an almost pure wood of *Juglans regia* L. From 800 to 600 m. altitude the downward slope was gradual, and for 100 m. or more on each side of the stream a primitive forest occurred with *Juglans regia* L. and *Ostrya carpinifolia* Scop. as the co-dominant trees but mixed with fairly numerous individuals of *Fagus orientalis* Lipsky, and some of *Quercus sessiliflora* Salisb., *Corylus colurna* L., *Carpinus orientalis* Mill., and *Fraxinus ornus* L. There was practically no undergrowth, even the *Ostrya* forming fine trees to 20 m. or more in height. A stream ran down the valley, which was cool and moist. It was very obvious that the *Juglans* and

Fagus kept to the moist, relatively shady, valley, near to the stream. *Ostrya* and *Carpinus* went higher up the slopes beyond the moister air of the valley, and *Quercus sessiliflora* was co-dominant with other oaks over all the hills up to 1,000 m. where it was replaced by *Fagus silvatica* L. Some trees of *Alnus glutinosa* Gaertn. overhung the stream. Isolated trees of *Fagus orientalis* were traced down to 550 m. altitude. The ground-flora was sparse, but *Circaea lutetiana* L., *Pteris aquilina* L., *Hypericum degenii* Bornm., *Scutellaria albida* L., *Poa nemoralis* L., *Mercurialis perennis* L., *Oxalis acetosella* L., and species of *Euphorbia*, *Salvia*, and *Campanula* occurred. We had the impression of being in a Tertiary forest.

C. Of the Central European Domain.

The whole of the north-central, north-eastern, and central parts of the Balkan Peninsula come within the Central European climatic zone and the flora corresponds. The ecological subdivisions of the forest-clad areas are chiefly dependent on altitude. In the lowland and hill zones, oak woods predominate, with beech and conifer woods mainly limited to the montane and lowest high mountain zones.

Oak woods. Woods dominated by oaks have a very wide extension in the Balkan Peninsula, where they occur especially in the lowland and hill zones. Often they form pure or almost pure communities but sometimes merge into mixed deciduous forest. The following species are to be found in most of the central districts: *Quercus conferta* Kit., *Q. cerris* L., *Q. robur* L., and *Q. sessiliflora* Salisb. Species with a less wide distribution are: *Q. brutia* Ten, and *Q. pendulina* Kit. The dominance of one or another species varies locally, and sometimes two or more are approximately equally dominant. Species here and there associated with the oaks are *Fraxinus excelsior* L., *Ulmus campestris* L., *Fagus silvatica* L. (usually at the higher limits, as on the Suva Planina), *Tilia tomentosa* Moench., *Acer campestre* L., *Juglans regia* L., *Prunus avium* L., and *Carpinus betulus* L. More rarely *Pyrus* spp., *Populus* spp. *Acer* spp., *Ostrya carpinifolia* Scop., and *Castanea sativa* Mill. occur. The undergrowth is often fairly well developed, with such species as *Prunus spinosa* L., *Corylus avellana* L., *Ligustrum vulgare* L., *Cornus sanguinea* L., *Cornus mas* L., *Crataegus monogyna* Jacq., *Sambucus nigra* L., *Euonymus europaeus* L., *Viburnum lantana* L., *Cytisus* spp., *Genista* spp., and *Rhamnus* spp. The undergrowth is generally rich and includes many common Central European woodland plants. Between Čakal and Kilere at about 500 m. altitude in the southern Rodopes I have seen *Juniperus communis* L. and *J. oxycedrus* L. forming undergrowth to oak woods. Some individuals of *J. oxycedrus* had the loranthaceous species *Arceuthobium oxycedri* Bieb. as a para-

site. On the Karlik Dagh, at about 1,000 m. altitude, I studied, in July 1926, primitive mixed oak and beech woods on a siliceous substratum. Here, on the frontier, no exploitation had occurred. The oaks were *Quercus sessiliflora* Salisb., *Q. cerris* L., and *Q. lanuginosa* Thuill. A few bushes of *Rubus* formed the only undergrowth, but humus was present in quantity, the ground thus forming a marked contrast with that of 'exploited' forests and denuded hill-sides.

Sweet-chestnut woods. *Castanea sativa* Mill. forms consociations in the higher parts of the hill zone and the lower part of the montane zone, often on non-calcareous soils. It is more frequently accompanied by oaks and the trees found in oak woods.

Beech forests. Pure or almost pure communities of *Fagus silvatica* L. are the characteristic forests of the montane zone in the Central European domain of the Balkan Peninsula. In general the beech occurs in the dampest altitudinal zone. That this happens to coincide with altitudes from 700–1,000 m. up to 1,400–1,500 m. is one of the reasons for the higher altitudinal limits of the species in south-eastern Europe, than in the rest of the continent, where the tree flourishes best under a relatively oceanic type of climate; at least it is not naturally distributed far east of the West Russian frontier. Under the climatic conditions existing on many mountains the beech has very considerable power of rejuvenation after the lumbering of an area, if sufficient time is allowed by the cessation for a period of man's destructive activities. This struck me forcibly in a study of the Suva Planina in 1922. On parts of this massif the beech forests had been deprived of all mature trees, but a brushwood, in places dense, of saplings of the same species was growing up. In one area this was being illegally destroyed by lime burners. I failed to find any of the conifers which had been reported by previous investigators. In the montane beech forests *Fagus silvatica* L. is sometimes unaccompanied by other tree species over considerable areas, but often both broad-leaved and coniferous species accompany it, so that beechwood may merge into a mixed forest of deciduous and evergreen species. The most important associates of the beech are: *Carpinus betulus* L., *Acer platanoides* L., *A. pseudoplatanus* L., *Betula verrucosa* Ehrh., *Populus tremula* L., *Ulmus scabra* Mill., *Pyrus aucuparia* Gaertn., *P. torminalis* Ehrh., *P. aria* Ehrh., *Picea abies* Karst., *Abies alba* Mill., *Pinus silvestris* L., *P. peuce* Griseb., and *Corylus colurna* L. The undergrowth often consists of *Juniperus communis* L. vars., *Vaccinium myrtillus* L., *Salix capraea* L., *Alnus viridis* DC., *Pinus montana* Mill., *Lonicera* spp., *Ribes* spp., and *Daphne* spp. The ground flora is not usually well developed in pure beech woods, but in the mixed beech woods it is rich in species, mostly such as have a wide general distribution in Central Europe and Eurasia. The finest beech-trees I have seen

are some of those in the Rila valley. Here there is little undergrowth, but the humus-rich soil extends to a depth of 30 cm. even on steep slopes. The ground flora in the shady parts is chiefly composed of *Poa nemoralis* L., *Geranium macrorrhizum* L., *Asperula odorata* L., *Asarum europaeum* L., *Euphorbia amygdaloides* L., *Oxalis acetosella* L., *Paris quadrifolia* L., *Epipogon aphyllus* Swartz, *Monotropa hypopitys* L., *Neottia nidus-avis* Rich., *Dentaria bulbifera* L., *Hedera helix* L., *Luzula albida* DC., *Pulmonaria rubra* Schott et Kotschy, and *Fragaria vesca* L.

Conifer forests. In the higher mountains coniferous communities cover extensive areas. Their relationship to the beech community varies a good deal in different districts. Sometimes the conifer and beech communities merge together and both reach to the tree limit. In other places a girdle of conifers occurs above the beech forest.

Pinus nigra Arn. in scattered localities in Serbia, Bulgaria, and the Rodope massif forms usually a nearly pure community in the higher parts of the hill and the lower parts of the montane zones. As undergrowth in such a community in the Zlatibor district Adamović (1909) records: *Juniperus communis* L., *Erica carnea* L., *Bruckenthalia spiculifolia* Reichb., and *Daphne blagayana* Freyer.

The *omorika* spruce society is the most limited of the conifer communities now under consideration. *Picea omorika* Willk. is one of the most typical of the Tertiary relicts of the Balkan Peninsula. It is limited to the mountains around the central and upper parts of the Drina basin in western Serbia and eastern Bosnia, and to a small area in Montenegro. The trees usually grow on steep hill-sides not exposed to the extreme conditions of ridges and summits. Other elements are usually present in the woods mixed with the omorika, and according to Wettstein (1890) include: *Pinus silvestris* L., *Picea abies* Karst., *Abies alba* Mill., *Fagus silvatica* L., and *Acer pseudoplatanus* L. The undergrowth is not well developed on account of the denseness of the trees, but *Rhamnus fallax* Boiss., *Lonicera alpigena* L., *Spiraea cana* W. et K., *Corylus avellana* L., and *Rhus cotinus* L., occur. The omorika spruce does well in cultivation. Some of the finest trees in the Belgrade Botanic Garden in 1922 were of this species, and at Kew it flourishes better than most other conifers.

Fairly pure consociations of *Picea abies* Karst. and *Pinus peuce* Griseb. occur locally in the central parts of our area and a belt of these conifers is frequently found above the beech on the higher mountains. In 1926 in a wild valley between Čamkorija and Rila I passed through an open wood of *Pinus peuce* and thought that its tall grey trunks and graceful foliage made it the handsomest of the European pines.

Fir woods are only locally found pure in the central parts of the Balkan Peninsula at the present time. The fir has been much destroyed

Mt. Pirin, western Rodope massif. A photograph taken from the conifer zone, about 1,700 m., with *Abies alba* dominant. Other conifers here are *Pinus silvestris*, *P. peuce*, *P. leucodermis* and *Picea abies*. The first three form the tree limit.

A valley in the western Rodopes, showing the junction of the beech and conifer zones at about 1,700 m.

by lumbering and, like other conifers in our area, appears to have less power of rejuvenation than the oaks and the beech. The species occurring in the Central European domain is *Abies alba* Mill. and this is in the main vicarious with the southern *A. cephalonica* Loud. The most frequently associated species are: *Picea abies* Karst., *Fagus silvatica* L., *Pinus silvestris* L., *Betula verrucosa* Ehrh. and *Populus tremula* L.

In the Rodopes mixed conifer forests still cover considerable areas. Thus near Čepelare woods of *Picea*, *Abies*, and *Pinus nigra* Arn. were only beginning to be exploited in 1926. Small woods of *Abies alba* Mill. occur on the Karlik Dagh near the summit, on both sides of the frontier. They are frequently mixed with *Fagus silvatica* L. Above Bačkova on the steep mountain slopes a wood dominated by *Abies alba* was being prepared for destruction in July 1926. In its upper parts it was fairly pure fir, but below there was a considerable mixture of other trees, including *Fagus silvatica* L., *Pinus silvestris* L., *P. nigra* Arn., *Ostrya carpinifolia* Scop., *Pyrus aucuparia* Gaertn., *P. torminalis* Ehrh., *Acer opalus* Mill., *A. platanoides* L., *Fraxinus excelsior* L., and *Tilia platyphyllos* Scop. The undergrowth of *Cotoneaster tomentosa* Lindl., and *Lonicera xylosteum* L. was very sparse, but the open ground vegetation included *Neottia nidus-avis* Rich., *Epipogon aphyllus* Swartz, *Corallorhiza trifida* Chât., *Monotropa hypopitys* L., *Goodyera repens*, R. Br., *Pyrola secunda* L., *P. minor* L., *Polygonatum pruinosum* Boiss., *Lilium martagon* L., *Orchis maculata* L., *Listera ovata* R. Br., *Cypripedium calceolus* L., *Cephalanthera rubra* Rich., and a species of *Epipactis*. In the Rila Valley the magnificent primitive woods are probably the finest in Europe. While they are largely mixed, with fir, spruce, and beech on the whole co-dominant, there are local patches of one or the other of these in almost pure societies. No cutting is allowed in this area, which is reserved to the Bulgarian nation, and the humus is deep even on the slopes. Tall trees blown down by storms rot away where they have fallen, and all stages of their decay can be traced down to a stretch of wood humus. Around Čamkorija the woods are predominantly of *Abies alba* Mill., with its var. *acutifolia* Turrill, often almost pure over considerable areas. *Picea abies* Karst. is in some places co-dominant with the fir. Many of the full-grown trees of these two conifers reach to a height of 25 m. or more and have their branches festooned with lichens. The undergrowth is very sparse, and seedlings and saplings of the conifers and a few scattered shrubs of the common beech form what there is. The ground-flora in the dense wood is also poor, and consists largely of mosses and liverworts, with *Melampyrum silvaticum* L., *Vaccinium myrtillus* L., *Pyrola uniflora* L., *P. chlorantha* Sw., *Oxalis acetosella* L., *Fragaria vesca* L., *Neottia nidus-avis* Rich., and *Corallorhiza trifida*

Chât. In open places where the trees have been cut or blown down the flora is much richer and is of a heath-like nature, with *Potentilla erecta* Hampe, *Campanula hemschinica* C. Koch, *Veronica officinalis* L., *Bruckenthalia spiculifolia* Reichb., *Hieracium* sp., *Actaea spicata* L., *Salvia glutinosa* L., *Astrantia major* L., and *Impatiens noli-tangere* L., with a shrub layer of species of *Lonicera*, *Euonymus*, *Ribes*, and *Rubus*, including *R. idaeus* L. In wetter places, on the sides of rivulets, or on moist banks, there occur: *Chrysosplenium alternifolium* L., *Caltha palustris* L., *Galium palustre* L., *Myosotis scorpioides* L. sensu Hill, *Prunella vulgaris* L., *Crepis paludosa* Moench, *Orchis maculata* L., *Petasites albus* Gaertn., *Cirsium appendiculatum* Griseb., *Ranunculus serbicus* Vis., *Geranium robertianum* L., *Veronica latifolia* L., *Buphthalmum speciosum* Schreb., and *Doronicum austriacum* Jacq.

BRUSHWOOD COMMUNITIES.

These are very extensively developed over wide areas in the Balkan Peninsula. The lowland, hill, and montane brushwoods are rarely if ever natural climatic climaxes. They either represent the undergrowth of forests from which the high trees have been removed by lumbering or other modes of destruction, or they are stages of subseres. The high mountain zone of brushwood ('subalpine') is often a natural climax formation, but its limits may be modified by man's interference, being increased at the expense of high mountain forest or decreased to the advantage of pasture. The floristic composition of the brushwood varies greatly within both the Mediterranean and Central European domains, both altitudinally and geographically. The chief ecological differences are between the evergreen hard-leaved Mediterranean macchie and their degenerate derivatives on the one hand and the deciduous shiblyak of the Central European domain on the other, while the high mountain brushwood differs from both.

Macchie. Macchie occur in all the true Mediterranean districts of the Balkan Peninsula. Most often typical macchie are limited to localities near the sea-coast, but in Crete and in southern Greece they extend considerable distances inland and to fairly high altitudes. Essentially, macchie consist of hard-leaved evergreen shrubs. The luxuriance varies much, but the list of species is, for our area, a very definite one, and though all do not occur in any one locality, the general composition has rather narrow limits of variation. Ecologically, the community is one of the best defined in the Balkan Peninsula, and this in spite of the fact that it is often historically the undergrowth of destroyed forests, frequently of *Pinus halepensis* Mill. The characteristic evergreen habit and winter or spring-flowering of most of the main constituents is obviously related to the climatic peculiarities of the

Mediterranean domain. It is emphasized in Chapter III that the coincidence of the dry and hot seasons, and of the wet and cooler seasons, is particularly well marked in the typical Mediterranean stations for which figures are available. The winter is not, therefore, the main 'resting' period or summer the main period of activity for the vegetation, as in the Central European domain. On the contrary, the summer drought is often a greater limiting factor to vegetative activity than winter cold. Snow and frost are rare or absent in winter when the precipitation in the form of rain is usually sufficient for all kinds of vegetation. Growth and flowering are therefore most noteworthy in winter and spring, and only a few species and individuals of typical macchia plants flower and grow in the height of summer. The macchia shrubs, to use a gardening phrase, require a long period of growth and warmth to ripen their wood.

True macchie are limited to the Mediterranean domain, and in those districts which on the whole verge towards the Central European type of climate, macchie are either absent or are limited to a few localities where the climate is most decidedly Mediterranean. The distribution of the macchie in Istria, Macedonia, and Thrace is most instructive from this point of view. In Istria, fully developed macchie only occur in positions sheltered from the bora. In Macedonia and Thrace macchie are developed very locally where protection is obtained from northern winds (such as the Vardar winds) and the sea is close at hand, often in more than one direction. Thus in South Macedonia they are found here and there in the Khalkidikē Peninsula, and in Thrace in the Gallipoli Peninsula. The known distribution of macchie in the Balkan Peninsula can best be given by considering their occurrence in individual districts.

In Crete macchie are well developed in the higher parts of the hill zone. They occur here and there on the sea-coast, but in most of the lowlands and on the lower hill-slopes phrygana is the characteristic plant community. Rikli records remains of uniform macchie on the sea-coast only near Argale, where they consisted of *Pistacia lentiscus* L., *Ceratonia siliqua* L., *Calycotome villosa* Link, *Smilax aspera* L., and wild olives. Above 660 m. macchie are more frequent and more luxuriant, typical species being *Erica arborea* L., *Arbutus unedo* L., *Quercus coccifera* L., *Calycotome villosa* Link, *Spartium junceum* L., *Smilax aspera* L., and *Asparagus acutifolius* L.

In Greece the true macchie (as distinguished from pseudomacchie and phrygana) are characterized by *Spartium junceum* L., *Cercis siliquastrum* L., *Myrtus communis* L., *Cotinus coggygria* Scop., *Erica arborea* L., *Arbutus unedo* L., *A. andrachne* L., *Olea europaea* L., *Phillyrea media* L., *Globularia alypum* L., *Quercus ilex* L., *Q. coccifera*

L., *Juniperus phoenicea* L. and *Pinus halepensis* Mill. The richness of the ground flora varies with the density of the shrub layer, but is typically Mediterranean and mostly early spring flowering. The macchie are far better developed on the western side of Greece than on the eastern. This is largely due to the moister climate and also to the position of the larger city-states on the eastern sea-board. The drier climate combined with the greater destruction for human use of trees and shrubs in the east led to more complete denudation and prevention of rejuvenation of forests and brushwoods in Attica and adjacent departments than on the west. Thus phrygana is the most widely dispersed type of plant-community on the eastern hills. There is no doubt that in Greece macchie formerly had a much wider extension. The macchie very frequently are themselves a stage in a subsere started by the biotic factor of human activity. It is certain that for extensive stretches of lowland and hill zone in the Mediterranean domain the natural climax formation is *Pinus halepensis* high-forest with macchia undergrowth. All stages between this and treeless macchie may be studied in Greece and other parts of the Mediterranean domain of our area. In the other direction, macchie pass gradually or suddenly into phrygana, while at higher altitudes in Greece and at lower altitudes in the climatically transitional districts they merge into pseudomacchie. Macchie occur very sparingly on the Cyclades and mostly on the smaller islands. This again is certainly due to man's activities and not to climatic conditions.

In the lower zones in Thessaly and Epirus macchie are well developed. The limiting factor of cold winds from the Pindus range, apart from mere altitude, prevents their further extension inland, very noticeably in Epirus. They clothe the coasts of the Gulf of Arta and many of the surrounding hills with thickets which are often impenetrable. Characteristic species here are: *Pistacia lentiscus* L., *Myrtus communis* L., *Olea europaea* L., *Phillyrea media* L., *Erica arborea* L., *Arbutus andrachne* L., *A. unedo* L., *Quercus ilex* L., and *Cercis siliquastrum* L., but *Spartium junceum* L., and *Juniperus phoenicea* L. are absent (Halácsy 1894). Prevesa is surrounded by typical Mediterranean vegetation, yet within a few hours' ride of the city the influence of cold winds from the Pindus is felt, and the macchie disappear to be replaced by hardier communities. Very few portions of Corfu have not been interfered with by man, but in several specially protected or neglected spots there are to be found macchie of *Quercus ilex* L., *Q. coccifera* L., *Erica verticillata* L., *Arbutus unedo* L., *A andrachne* L., *Pistacia lentiscus* L., and *P. terebinthus* L. In Albania macchie occur on the coast and penetrate inland only in the lowlands and up the valleys.

In South Macedonia the true macchie are found only on the coastal

slopes of the Athos Peninsula and some of the neighbouring central and eastern parts of the Khalkidikē Peninsula up to about 200 m. altitude. The principal constituents are: *Arbutus unedo* L., *A. andrachne* L., *Erica verticillata* Forsk., *E. arborea* L., *Juniperus oxycedrus* L., *Buxus sempervirens* L., *Calycotome villosa* Link, *Cistus villosus* L., *Laurus nobilis* L., *Spartium junceum* L., and wild olives. Macchie of very similar composition occur in Thrace along the sea-coasts of the Aegean and Marmara seas and even on the Bosporus. They are chiefly limited to the more sheltered bays, slopes, and valleys, and in many localities are replaced by phrygana or pseudomacchie. True macchie do not occur in South Bulgaria, and their limits on the Bosporus or Thracian Black Sea shore are not known.

In Dalmatia the macchie are frequently and often luxuriantly developed along the coast south of Sebenico and in the islands in the northern parts, while in the Quarnero and Istria the macchie become less frequent and less luxuriant, and a number of characteristic species are lacking.

The following accounts of the South Dalmatian macchie were drawn up in the field in 1925. On the Lapad Peninsula the woody vegetation has been relatively well protected up to the present. The dominant tree is *Pinus halepensis* Mill., and there are fine examples of this in closed associations on Mt. Petka. Where the woods are open a luxuriant undergrowth of macchia is developed, and where the trees have been cleared this remains either as high, but treeless, macchia or shows (as at the southern end of the peninsula) gradual degeneration to phrygana and herbaceous stony-ground vegetation. In the poorer macchie *Pistacia lentiscus* L. and *Juniperus phoenicea* L. are dominant, accompanied by a good deal of *Calycotome infesta* Guss. Sprawling branches and intertwining shoots of *Smilax aspera* L., and *Asparagus acutifolius* L. often cover the shrubs. Other constituents are: *Phillyrea media* L., *Erica arborea* L., *E. verticillata* Forsk., *Rosmarinus officinalis* L., *Juniperus oxycedrus* L., *Phlomis fruticosa* L., *Ruscus aculeatus* L., and *Paliurus spina-Christi* Mill. At the base of Mt. Petka, on the margins of the pine forest, the macchie are particularly luxuriant and dense. High bushes of *Myrtus communis* L., small trees of *Quercus ilex* L., *Fraxinus ornus* L., and wild olives, and lower shrubs of *Juniperus oxycedrus* L., *Pistacia lentiscus* L., *Spartium junceum* L., *Osyris alba* L., *Erica arborea* L., *E. verticillata* Forsk., *Cistus salviifolius* L., and *C. villosus* L. form a rich and attractive community. On the side towards Gruž (Gravosa) *Laurus nobilis* L., *Cercis siliquastrum* L., *Paliurus spina-Christi* Mill. and *Quercus cerris* L. are associated with the more typical macchia shrubs. The island of Lacroma near Dubrovnik (Ragusa) has the best developed Mediterranean wood communities in

Dalmatia. At the southern end of the island is a high forest of *Pinus halepensis* Mill. with macchia undergrowth, and on the northern side is a dense macchia with *Arbutus* dominant. In the tallest parts high shrubs, even attaining 8 to 12 m. and with the dimensions and trunk-development of trees, of *Arbutus unedo* L., *Phillyrea media* L., and *Juniperus phoenicea* L. form dense thickets, made more impenetrable by the strong prickly festoons of *Smilax aspera* L. The ground-flora is practically absent here, though dwarf shrubs of *Ruscus aculeatus* L. and *Asparagus acutifolius* L. occur when space is available. Less abundant, but in places important, constituents of the macchie are: *Pistacia lentiscus* L., *Myrtus communis* L. (especially the var. *communis*, though I also found a few examples of the var. *tarentina*), *Erica arborea* L., *E. verticillata* Forsk., *Ceratonia siliqua* L., *Olea europaea* L. var. *oleaster*, *Coronilla emerus* L., *Juniperus oxycedrus* L., *Calycotome infesta* Guss., *Quercus ilex* L., *Rosmarinus officinalis* L., and *Laurus nobilis* L. North of Sebenico the macchie are much more limited in distribution, occurring mainly on the islands and in a few protected places on the mainland.

Macchie extend north to about half way up the western coast of Istria, where in 1922 I studied a macchia of moderately luxuriant type just south of Parenzo, almost at its northern limit. The macchie here are developed only where shelter is obtained from the bora, on the southern slopes of small bays, and where the soil is calcareous. The species occurring include: *Spartium junceum* L., *Olea europaea* L., *Juniperus oxycedrus* L., *Asparagus acutifolius* L., *Quercus ilex* L., *Phillyrea media* L., *Osyris alba* L., and *Paliurus spina-Christi* Mill. A small area of similar poor macchia occurs near Duino at the extreme north of the Adriatic, with *Quercus ilex* L., *Pistacia terebinthus* L., *Osyris alba* L., and *Smilax aspera* L. mixed with a good many representatives of the karst brushwoods. Of the Quarnero islands, Arbe, Lussin, the south-western parts of Cherso, the southern part of Veglia, and possibly Pago, belong to the Mediterranean region. Typical macchia is only found near the sea, though scattered 'enclaves' of macchia species may go up to 300 or 400 m. On the north side of Mt. Ossero, where the bora is most felt, depauperated macchie only reach to 100 m. altitude.

The influence of the bora on the development of the macchie is more physiological than mechanical. The drying effect of this wind is well known, and in the spring its effect on the young shoots and early leaves is often most marked since it causes them to wilt, to become discoloured, and to die off. Moreover, the salt spray carried by this wind is very inimical to some of the macchia constituents. *Laurus nobilis* L. and *Viburnum tinus* L. are particularly susceptible, and these shrubs

High macchie merging into *Pinus halepensis* wood. On the Lapad Peninsula in Dalmatia, overlooking the Adriatic Sea.

Depauperated macchie on stony limestone ground in the Lapad Peninsula and looking towards the island of Lacroma.

are rarely found in macchie immediately bordering the coast where this is subject to the direct action of the bora. On the other hand, *Myrtus communis* L. and *Pistacia lentiscus* L. may survive almost as half-halophytes. Schiller (1907) has suggested that the growth of the macchie in regular strips with rounded contours, as seen frequently on the northern coasts and islands of the Adriatic, may be due to the action of the bora. The influence of the scirocco on the vegetation is quite secondary to that of the bora in areas where both occur, but may sometimes be noticed, especially by the results of salt incrustations following the sea spray which it often carries.

Pseudomacchie. This name was proposed by Adamović (1906) for xerophilous, evergreen brushwoods of the Mediterranean lands, which predominantly inhabit the submontane and montane region and cover the scarps of the hills and mountains. They are ecologically and floristically related to true macchie, but I agree with Adamović in regarding them as constituting essentially a distinct community (or group of communities) with different climatic limitations. The true macchie, except in Crete and Greece are almost entirely limited to the lowlands near the coast. The pseudomacchie are characteristic of the hill and montane zones in the Mediterranean and transitional domains of the Balkan Peninsula. Since the constituent species can withstand lower temperatures and a shorter growing season, they extend farther north and farther inland, as well as to higher altitudes, than the macchie. This is particularly noticeable in the transitional but essentially Mediterranean districts, such as South Macedonia. Floristically, a macchia is a mixed community with one species rarely dominant over very wide areas. While macchie vary in luxuriance and locally to some extent in the constituent species, they have a general ensemble which is quite different from that of the pseudomacchie. In the latter, one species is often dominant over fairly wide areas, but this dominant is different in different areas. Some of the dominants, and also some of the subordinate species, are of common occurrence in the true macchie, but the general association of species is quite different. The following species characteristic of macchie do not occur in the pseudomacchie: *Arbutus unedo* L., *A. andrachne* L., *Myrtus communis* L., *Juniperus phoenicea* L., *Erica arborea* L., *E. verticillata* Forsk., *Pistacia lentiscus* L., *Rosmarinus officinalis* L., *Olea europaea* L., and *Quercus ilex* L. The following species are important elements of the pseudomacchie, but are rare or absent from true macchie: *Juniperus excelsa* Bieb., *Quercus macedonica* Griseb., *Buxus sempervirens* L., *Prunus laurocerasus* L., *Pistacia terebinthus* L., and *Jasminum fruticans* L. The following are the dominating species of pseudomacchie: *Juniperus oxycedrus* L. (of very wide distribution in the Balkan Peninsula and by no means

limited to the pseudomacchie); *J. excelsa* Bieb. (just into North Macedonia, South Macedonia, Thrace, and the Rodope); *Juniperus drupacea* Lab. (only in Greece and Thessaly); *Buxus sempervirens* L. (especially characteristic of pseudomacchie in Albania and North and South Macedonia); *Quercus macedonica* Griseb. (Epirus, Albania, North Macedonia, South Macedonia, Montenegro, and Hercegovina); *Q. coccifera* L. (of wide distribution in the Mediterranean and transitional districts where it frequently forms a dominant element in pseudomacchia over wide areas); *Prunus laurocerasus* L. (of local occurrence in scattered localities). Important associates of the dominant species are: *Jasminum fruticans* L., *Phillyrea media* L., *Ilex aquifolium* L., *Spartium junceum* L., *Calycotome infesta* Guss., *C. villosa Link*, *Colutea arborescens* L., *Laurus nobilis* L., *Pistacia terebinthus* L., *Rubus* spp., *Prunus spinosa* L., *Paliurus spina-Christi* Mill., *Cotinus coggygria* Scop. and *Crataegus* spp. Liane elements also occur as: *Smilax aspera* L., *S. excelsa* L., *Clematis* spp., *Cynanchum acutum* L., *Lonicera* spp., *Asparagus acutifolius* L., and *Hedera helix* L.

The pseudomacchie are, so far as I can judge from my own experience, usually more easily distinguished from the macchie than from the shiblyak, though this may not be true for the south of Greece. Certainly in the inland parts of South Macedonia pseudomacchie of *Quercus coccifera* L. pass into shiblyak without any sharp line of demarcation (Turrill 1918). Thus on the hill-slopes immediately to the north of Salonika (Lembet or Lembert hills) pseudomacchia of almost pure *Quercus coccifera* L. covers considerable areas, but on the northern slopes of the Krusa Balkan, a characteristic community, consisted of the kermes oak with *Juniperus oxycedrus* L., *Fraxinus ornus* L., *Pistacia terebinthus* L., *Cotinus coggygria* Scop., *Cornus sanguinea* L., *Acer campestre* L., and species of *Crataegus*, *Rosa*, and *Rubus* and in the hollows *Quercus coccifera L.*, *Jasminum fruticans* L., *Paliurus spina-Christi* Mill., and *Carpinus orientalis* Mill. Floristically and ecologically, pseudomacchie stand between true macchie and the shiblyak, and their history is also probably intermediate. The macchie, on the whole, probably represent the undergrowth of destroyed forests, and the shiblyak is most often a stage in a secondary succession initiated by forest destruction. The pseudomacchie consist of species some of which are found as undergrowth in forests or are even members of the tree layer and of species which are typical of treeless brushwood and do not occur usually in the forests of the hill and montane zones. The pseudomacchie are not degenerate forms of macchie but are brushwoods, of usually predominating evergreen species, which may reach to as great a luxuriance as any macchia. The biotic factor of herds of sheep and goats frequently results in depauperation of the pseudomacchie, which

then pass over into a form of phrygana, as is well seen on many South Macedonian hill-slopes. The pseudomacchie would undoubtedly pass into oak or mixed forests in many areas if man's destructive influences were restrained for a period of thirty or forty years. The succession and its rate would vary considerably according to the kind of pseudomacchia and its position. Thus on parts of the Krusa Balkan, where shiblyak and pseudomacchie merge, individuals of tree species were already present in 1917 and thick, mixed deciduous forest could have quickly developed. On the Lembert Hills, on the contrary, the process would be slow, since invasion and ecesis would have first to occur and a practically new succession be initiated. The ground-flora accompanying the pseudomacchie is frequently rich in species but varies very greatly with the district. The floristic composition may be rather phytogeographical than truly ecological. The bushes frequently shelter herbaceous plants which cannot flourish in the barer ground owing to the lack of superficial moisture, and, if they be prickly as the kermes oak, give protection from omnivorous animals.

Phrygana. Large areas especially of dry hill-slopes in the Mediterranean and transitional districts are covered with an open growth of low, shrubby plants. The term 'phrygana' was applied collectively to these by Theophrastus[1] and is still in use by the Modern Greeks. The phrygana form communities similar to the *garigues* (a Provençal word) of South France and the *tomillares* of Spain, but on the whole xeromorphic structure is more marked in the eastern phrygana. Phrygana is widely distributed in the lower and hill zones in Crete, Greece, the Cyclades, Thessaly, Corfu, South Macedonia, Thrace, and Dalmatia. The dominant plants are dwarf, shrubby, or suffruticose species which are frequently spiny or prickly. Characteristic species are: *Coridothymus capitatus* Reichb., *Poterium spinosum* L., *Thymelaea tartonraira* All., *Genista acanthoclada* DC., *Euphorbia acanthothamnos* Heldr. et Sart., *Anthyllis hermanniae* DC., *Hypericum empetrifolium* Willd., *Satureia thymbra* L., and *Thymelaea hirsuta* Endl., with remnants of the macchie as *Cistus* spp., *Erica verticillata* Forsk., and *Quercus coccifera* L. Among the sub-shrubs or in their shade a rich vegetation of herbaceous plants occurs with therophytes and geophytes predominant.

[1] To Theophrastus the term meant under-shrubs, i.e. what we should now consider a life-form category, not a plant community in the synecological sense. Thus in his *Enquiry into Plants* I. iii. 1 he defines an under-shrub (*φρύγανον*) as 'a thing which rises from the root with many stems as well as many branches; for instance, savory rue'. The term is used as co-equivalent to tree, shrub, and herb. Book VI is entirely devoted to the subject of under-shrubs, but the implied definition, 'for all these are woody and have small leaves' is different from that first quoted. Space is not here available for a discussion of the changes in the use of this term. It is now usually applied, as a singular or plural word, to the type of vegetation described in this section.

Heldreich counted more than 200 species for the Attic phrygana. The majority of the phrygana constituents and their associated herbs flower in the early spring and up to May; in June *Genista acanthoclada* DC. is the flowering dominant; and in full summer scarcely any other plants than *Labiatae* and thistles are in flower. In March and April bulbous plants of the genera *Muscari*, *Ornithogalum*, *Fritillaria*, *Gagea*, *Lloydia*, and *Romulea* are most conspicuous.

Phytogeographically oriental and eastern Mediterranean species are the best represented in the phrygana and amongst the herbaceous associates, and it is of interest to note that several species occur which are at least in part vicarious with species in the garrigue and tomillares of the western Mediterranean Basin. Examples are: *Euphorbia acanthothamnus* Heldr. et Sart. and *E. spinosa* L.; *Daphne sericea* Vahl and *D. collina* Sm.; *Phlomis fruticosa* L. and *P. lychnitis* L.; *Rhamnus graeca* Boiss. et Reut. and *R. oleoides* L.; *Hypericum empetrifolium* Willd. and *H. corris* L.; *Erica verticillata* Forsk. and *E. vagans* L. As indicating the xeromorphic habit the chief phrygana constituents may be classified as follows: small-leaved spiny or prickly shrubs, as *Rhamnus graecus* Boiss. et Reut., *Euphorbia acanthothamnus* Heldr. et Sart., *Anthyllis hermanniae* DC., *Quercus coccifera* L., *Poterium spinosum* L., and *Genista acanthoclada* DC.; shrubs and sub-shrubs with dense tomentum, as *Phlomis fruticosa* L., *Thymelaea tartonraira* All., *Thymelaea hirsuta* Endl., and *Cistus villosus* L.; under-shrubs of ericoid habit, as *Hypericum empetrifolium* Willd. and *Erica verticillata* Forsk.; and dwarf shrubs evaporating ethereal oils as *Coridothymus capitatus* Reichb., *Satureia thymbra* L., and *Micromeria juliana* Benth. The phrygana is often a degenerate form of macchie as in Crete and Greece, but sometimes of pseudomacchie as in those parts of South Macedonia not far from the coast. Thus on the hills above Salonika where the pseudomacchia has been depauperated by uprooting for fuel and the attacks of sheep and goats it is largely replaced by phrygana of *Poterium spinosum* L. and *Astragalus* spp. In Crete and Greece and in the southern portions of Thrace as the Gallipoli Peninsula (see Turrill 1924) the phrygana is partly derived from the pseudomacchie.

Shiblyak (**šibljak**). This is the vernacular name given in Serbia and other South Slavic parts of the Balkan Peninsula to deciduous brushwood. I found the name well known in the Nish area in 1922. While the shiblyak is characteristic of the Central European domain it also occurs in the transitional districts and even, at higher altitudes, in the Mediterranean domain. The shiblyak most often owes its origin to the human destruction of forests, in the sense that it has usually replaced them. Thus, on the route from Belgrade via Nish to Sofia we read in the histories of the Crusaders of the dense 'Silva Bulgarorum', but now

dense forest is absent and many of the hills are covered with shiblyak. On the other hand, shiblyak is not composed of forest undergrowth left after the high trees have been removed. Many of the characteristic species are light-demanding and certainly could not withstand the cool shade of forests. The great extension of the shiblyak is due to man, but it is a natural brushwood representing a biotic climax (or sub-climax) in a succession initiated after forest destruction and which would pass again into forest were the biotic factors entirely removed. The shiblyak occurs in nearly all the districts of the Balkan Peninsula and frequently begins where the true macchie cease. Reference has already been made to the transitions between pseudomacchie and shiblyak. In the more southern districts (Crete, Greece, Thessaly, Epirus, Thrace, Dalmatia, and parts of South Macedonia, Albania, and Montenegro) it is usually limited to the montane zone, but in the other more continental districts, it is very characteristic of the hill altitudinal zone. Phytogeographically the shiblyak is essentially a Pontic type of vegetation as is indicated by its general distribution and that of many of its most characteristic constituent species. The latter are: *Paliurus spina-Christi* Mill., *Cotinus coggygria* Scop., *Quercus lanuginosa* Thuill., *Syringa vulgaris* L., *Petteria ramentacea* Presl, *Berberis vulgaris* L., *Rhus coriaria* L., *Prunus* (*Amygdalus*) *nana* Stokes, *Viburnum lantana* L., and *Cercis siliquastrum* L. The dominant and associated components vary considerably for different localities. Thus near Sičevo, in south-eastern Serbia, I found in 1922 mixed shiblyak covering the hill-sides and consisting chiefly of *Quercus lanuginosa* Thuill., *Cornus mas* L., *C. sanguinea* L., *Crataegus monogyna* Jacq., *Viburnum lantana* L., *Cotinus coggygria* Scop., *Syringa vulgaris* L., *Acer campestre* L., *Pyrus* spp., *Carpinus orientalis* Mill., and *Corylus avellana* L. In South Macedonia in 1917 I had frequent opportunity of examining shiblyak of the *Paliurus* type on the southern edge of the Struma Plain. This shrub there grows up to 3 m. high and with its curved stipular thorns makes the often dense brushwood practically impenetrable. The community is often nearly pure or most decidedly dominated by the Christ's thorn. Occasionally, and especially higher up the slopes of the Krusa Balkan, *Jasminum fruticans* L. and *Cotinus coggygria* Scop. are locally dominant, or the brushwood merges into pseudomacchia by the incoming of *Quercus coccifera* L. and *Juniperus oxycedrus* L.

In Bulgaria shiblyak is widespread and is known to the inhabitants under several names, including *šumalak*, *gastalak*, *chrastalak*, and *baltalak*. In 1926 I observed much of it on the peculiar purple-red sandstones and other rocks of the Isker gorge of the Stara Planina, and again farther north between Vratsa and Lom Palanka on the Danube,

both on the Vračanska Planina from the base to the top and also on the flat ground. What trees there are have had the side branches pollarded, probably to provide fodder for domesticated animals. Around the Iron Gates and the Kasan Pass, on the Serbian side, the hills are also covered with shiblyak. South of Varna, in August 1926, I examined carefully on several occasions the composition of the luxuriant brushwood growing on sandy soil. Intermittent sheep-grazing is permitted on the hills amongst the shrubs, but this only occurs about one year in three and is not excessive. The woody plants are: *Paliurus spina-Christi* Mill., *Carpinus orientalis* Mill., *Quercus cerris* L., *Q. conferta*, Kit., *Q. lanuginosa* Thuill., *Fraxinus ornus* L., *Crataegus monogyna* Jacq., *Cornus sanguinea* L., *C. mas* L., *Coronilla emeroides* Boiss., *Acer campestre* L., *Viburnum lantana* L., *Pyrus torminalis* Ehrh., *Euonymus verrucosus* Scop., *Tilia tomentosa* Moench, *T. cordata* Mill., *Carpinus betulus* L. (much rarer here than *C. orientalis* Mill.), *Colutea arborescens* L., *Corylus avellana* L., and *Rosa* sp. In the lower growth *Ruscus aculeatus* L. and *Hedera helix* L. also occur, while *Clematis vitalba* L., and *Smilax excelsa* L. are associated lianes. The last-named species in places forms magnificent festoons with its dark green leaves and makes the brushwood impenetrable. The herbaceous ground-flora is exceedingly rich, especially in the open parts. Considered as a whole it is composed of a curious mixture of species usually associated with dry grassy or stony slopes or with woodlands, of species cosmopolitan in general distribution, and of species endemic to the Varna district. In Thrace inland from Chataldja I have seen considerable areas of shiblyak dominated by low oaks (*Q. cerris* L., *Q. conferta* Kit., and *Q. lanuginosa* Thuill.), *Paliurus spina-Christi* Mill., and *Tilia tomentosa* Moench. Some Mediterranean types, as *Spartium junceum* L. appeared locally.

High mountain brushwood. In Crete brushwood, more or less closed and decreasing in height with altitude, is formed largely of *Juniperus oxycedrus* L., and *Berberis cretica* L., associated with the low *Prunus prostrata* Lab. and *Daphne oleoides* Schreb. In the Greek mountains *Juniperus communis* L. var *hemisphaerica* Parl. and *Daphne oleoides* Schreb. are the principal constituents of the brushwood, associated with *Prunus prostrata* Lab., *Rhamnus prunifolia* S. et S., and *Astragalus* spp. In Albania it would appear that suffruticose plants, such as species of *Daphne*, *Dianthus*, *Astragalus*, *Nepeta*, *Sideritis*, *Thymus*, *Hedraeanthus*, *Achillea*, and *Gnaphalium*, are more characteristic of the zone immediately above the tree-limit than true brushwood, but communities with *Juniperus communis* L. var. *nana* Loud., *Pinus montana* Mill., *Rosa* spp., *Daphne oleoides* Schreb., and *Prunus prostrata* Lab. have been recorded by Baldacci. In the Illyrian districts

	Phrygana	*Macchia*	*Pseudomacchia*	*Shiblyak*
Lists of dominant and characteristic species	*Poterium spinosum* L. *Coridothymus capitatus* Reichb. *Thymelaea tartonraira* All. *T. hirsuta* Endl. *Genista acanthoclada* DC. *Euphorbia acanthothamnus* Heldr. et Sart. *Astragalus* spp. *Anthyllis hermanniae* DC. *Hypericum empetrifolium* Willd. *Satureia thymbra* L. *Erica verticillata* Forsk. *Quercus coccifera* L. (remnants)	*Arbutus unedo* L. *A. andrachne* L. *Myrtus communis* L. *Erica arborea* L. *Pistacia lentiscus* L. *Juniperus phoenicea* L. *Olea europaea* L. *Phillyrea media* L. *Quercus ilex* L. *Q. coccifera* L. *Cercis siliquastrum* L. *Spartium junceum* L. *Calycotome villosa* Link *C. infesta* Guss. *Cistus villosus* L. *C. salviifolius* L. *Rosmarinus officinalis* L. *Smilax aspera* L. *Laurus nobilis* L.	*Juniperus oxycedrus* L. *J. excelsa* Bieb. *J. drupacea* Lab. *Quercus coccifera* L. *Q. macedonica* Griseb. *Buxus sempervirens* L. *Prunus laurocerasus* L. *Pistacia terebinthus* L. *Jasminum fruticans* L. *Phillyrea media* L. *Ilex aquifolium* L. *Colutea arborescens* L. *Paliurus spina-Christi* Mill. *Cotinus coggygria* Scop. *Calycotome villosa* Link *C. infesta* Guss. *Asparagus acutifolius* L. *Acer campestre* L.	*Paliurus spina-Christi* Mill. *Cotinus coggygria* Scop. *Quercus lanuginosa* Thuill. *Syringa vulgaris* L. *Berberis vulgaris* L. *Rhus coriaria* L. *Petteria ramentacea* Presl *Cornus mas* L. *Acer campestre* L. *Viburnum lantana* L. *Carpinus orientalis* Mill. *Corylus avellana* L. *Cercis siliquastrum* L. *Coronilla emeroides* Boiss. *Colutea arborescens* L.
Vegetational nature	Results from excessive pasturing and tree and shrub destruction	Shrub layer of destroyed *Pinus halepensis* forest, or climatic climax, or biotic sub-climax in sere leading to *Pinus halepensis* forest, or a stage in degeneration to phrygana.	Biotic sub-climax leading to deciduous oak forest (*Quercus conferta*, *Q. pubescens*, and *Q. cerris*)	Biotic sub-climax corresponding to mixed deciduous forest
Life-form of dominants	Low shrubs and sub-shrubs and xeromorphic herbs	Mainly evergreen	Partly evergreen and partly deciduous	Mainly deciduous
Distribution in relation to climate	Mediterranean and transitional	Mediterranean	Mediterranean and transitional	Central European
Altitudinal distribution	From coast up to 800 m.	In Crete and Greece up to 800 m. or locally higher, but towards northern limits coastal areas only	From lowlands up to 1,000 m.	From lowlands up to 1,200 m.

Pinus montana Mill. and *Juniperus communis* L. var. *nana* Loud. are dominant constituents of the 'subalpine' brushwoods.

Through all the central parts of the Balkan Peninsula *Juniperus communis* var. *nana* is most frequently the dominant plant of the high-mountain brushwood. It varies locally in height, and there is a considerable range in the purity and density of the consociation it dominates or the association of which it is a constituent. In exposed situations it forms a carpet less than a decimetre thick, but under more favourable conditions the individual shrubs are higher, more distinct, and well formed. In the Rodopes I have seen it, as isolated individuals, extending to not far below the summit of Musala.

Consociations of *Pinus montana* Mill. are usual on many of the high mountains of Serbia, Bulgaria, and North Macedonia. Sometimes these are very dense, though they vary much in size and height. In the Rodope massif I have seen it fruiting well both in the form of small trees and as low shrubs.

Picea abies Karst. occurs sometimes in the middle high-mountain zone as a low, very dense tree or shrub. This has been described as var. *balcanica* by Velenovský (sub nom. *Picea excelsa* Link). I collected it on the Vitoša, but it has also been recorded from the Osogovska Planina and Kom. Probably it is only an ecad formed through upward extension of the species beyond the tree limit. *Fagus silvatica* L. and *Alnus viridis* DC. likewise extend in shrub forms above the tree limit on many mountains of the central parts of the Balkan Peninsula. Of low, dwarf shrubs occurring in, and sometimes dominating, high mountain communities mention may be made of *Bruckenthalia spiculifolia* Reichb., *Vaccinium myrtillus* L., *V. uliginosum* L., *V. vitis-idaea* L., and *Arctostaphylos uva-ursi* Spr. These can scarcely be described as forming brushwood, but the *Bruckenthalia* is especially a characteristic high mountain plant of the central Balkan Peninsula. It largely takes the place of *Calluna vulgaris* L. of the North European moors and is somewhat similar in habit, flower-colour, and habitat. Rhododendrons are rare in the Balkan Peninsular flora, though *R. kotschyi* Simk. occurs in high mountains in North Macedonia, North Bulgaria, and the Rodope massif. *Empetrum nigrum* L. is also of very local occurrence, though it is known from the Rodope massif, where it apparently reaches its southern limit in Europe.

GRASSLANDS.

It has been emphasized in the chapter on climate that the Balkan Peninsula is divided between the Central European and Mediterranean climatic zones, and the latter is Hellenic and continental as contrasted with the Portuguese or oceanic type. It would naturally be expected

that mesophytic grasslands are rare except in the high mountains. While on the Atlantic seaboard the destruction of forests frequently leads to the increase of closed pastures composed predominantly of mesophytic grasses, in the Balkan Peninsula the trees are most frequently replaced by brushwood which may degenerate to phrygana or communities on a stony or rocky substratum and with a usually open type of vegetation in which grasses are often not the dominant type of plant. These communities have largely a geophytic, therophytic, or xeromorphic flora and are considered under another heading.

High mountain meadows. Grasslands, really comparable to those of western Europe, only occur in our area in the montane and high mountain zones. They are particularly characteristic of the high mountain zone 2 (the 'subalpine' of many authors) and are generally used as summer pastures for flocks and herds. In the Mediterranean domain high mountain meadows are very poorly developed. So many of the mountains are composed of very porous limestone that water from the melting snows quickly percolates away. Moreover, especially in Greece, plateau formation is rare in the mountains, steep slopes being very common, and heavy rain and wind storms easily denude them of soil. There are also frequent and strong drying winds which are not favourable to mesophytic plants. It follows that open formations of xerophytic plants on stony and rocky ground are much commoner than closed meadow grassland. On the mountains in the transitional and Central European districts, on the contrary, high mountain meadow land is sometimes well developed, though it merges into bog and moor on the one hand and into stony and rocky habitats on the other.

Beck (1901) records for 'Voralpenwiesen', in the north-western districts of the Balkan Peninsula, the following species of grasses: *Anthoxanthum odoratum* L., *Briza media* L., *Dactylis glomerata* L., *Koeleria cristata* Pers., *Deschampsia caespitosa* Pal. de Beauv., *Festuca ovina* L., *Sesleria argentea* Savi, *Bromus erectus* Huds., *B. ramosus* Huds., and *Nardus stricta* L. These are accompanied by a very large number of other herbs largely of a Central European character. For the 'Alpenmatten' of the same area he records: *Sesleria tenuifolia* Schrad., *S. argentea* Savi, *S. caerulans* Friv., *Festuca paniculata* Schinz et Thell., *Poa alpina* L., *Nardus stricta* L., *Anthoxanthum odoratum* L., *Koeleria splendens* Presl, *Bromus transsilvanicus* Hack., *Phleum michelii* All., and *P. alpinum* L., again mixed with a great number of monocotyledonous and dicotyledonous herbs.

On the Kalofer Balkan of the Central Stara Planina Iwanow and Drenowsky (1912) describe meadow-like communities as well developed. From 1,900 to 2,373 m. dry meadows are common, with *Poa nemoralis* L., *P. alpina* L., *Luzula spadicea* Lam. et DC., *Sesleria caerulans* Friv., *S.*

comosa Vel., *Phleum gerardii* All., *Carex sempervirens* Vill., *C. atrata* L., *Festuca spadicea* L., *F. varia* Haenke, and *Juncus trifidus* L. A considerable number of attractive flowering plants, of which many are endemic, also occur. Wetter meadows pass over into bog and moor.

On the Vitoša between 1,800 and 2,200 m. there are extensive 'meadows' of rich herbaceous vegetation, which I studied in 1922. Grasses and grass-like plants are frequent and include *Poa alpina* L., *P. ursina* Vel., *Festuca violacea* Gaud., *F. varia* Haenke, *Luzula nemorosa* E. Mey., *L. spicata* Lam. et DC., *Juncus trifidus* L., and *Carex atrata* L. Mixed with these are great numbers of other herbs, such as *Polygonum undulatum* Murr., *P. bistorta* L., *Senecio carpaticus* Herbich, *Antennaria dioica* Gaertn., *Viola saxatilis* F. W. Schmidt, *Dianthus microlepis* Boiss., *Campanula alpina* Jacq., and other species, *Lilium carniolicum* Bernh., *Veratrum album* L., *V. nigrum* L., and species of *Allium*, *Geum*, *Pedicularis*, and *Galium*. The vegetation frequently passes into moor and bog.

In the meadow-like grassland of the high mountain valleys there is on the whole a higher percentage of forbs, i.e. of herbs other than species of *Gramineae*, than in English grasslands. The floristic richness of such habitats is indicated by the fact that on July 31, 1926, on a grassy slope in the Rila Valley not far from the monastery in an area of twelve square metres we counted in flower or fruit seventy species of Phanerogams. In damp meadow land at 1,600 m., near the upper limit of the beech forest, in the valley of the River Ilyina, the second valley from the Rila monastery, species of *Poa*, *Briza*, *Agrostis*, and *Cynosurus* were the chief grasses. These, however, were dominated by a great mixture of other herbs, amongst which the following were important: *Alectorolophus major* Reichb., *Lotus corniculatus* L., *Salvia verticillata* L., *Centaurea stenolepis* Kern. var. *razgradiensis* Hayek, *Chrysanthemum leucanthemum* L., *Silene roemeri* Friv., *S. angustifolia* Mill., *Prunella vulgaris* L., *Betonica officinalis* L., *Rumex acetosa* L., *Galium verum* L., *Nepeta violacea* Vill., *Achillea millefolium* L., *Tanacetum vulgare* L., *Gladiolus imbricatus* L., *Pedicularis comosa* L., *Mentha longifolia* Huds., *Orchis maculata* L. var. *saccigera* Reichb., *Viola saxatilis* F. W. Schmidt sensu Becker, and species of *Scabiosa*, *Trifolium*, *Crepis*, and *Euphrasia*.

Steppe-like grasslands. Steppes floristically and ecologically similar to those of southern Russia and to the Hungarian pusztas occur in North Bulgaria and the Dobruja. A careful consideration of the steppe vegetation with reference to the distribution of the individual species has led me to the conclusion that it is incorrect to speak of a large steppe flora in the sense of many species limited to, or most usually occurring, in the steppe vegetation. Exception must probably be made of

the flora of what is sometimes termed the salt-steppes, though many of the species of this formation also occur on the maritime salt-marshes of the Black Sea littoral. A detailed investigation of the distribution of the species listed in any of the accounts of the southern Russian or Hungarian steppes will convince an unbiassed investigator that the characteristic species of the steppe vegetation have a wide distribution far beyond the limits of the true steppe areas. Often these species occur in habitats different from the plains and rolling down country of true steppes and in associations very different from those of the steppes. Each species of the steppe vegetation has its own range of distribution and, outside the steppe areas, it is not usual to find the species especially characteristic of the steppe associated together. Many authors have felt a difficulty in defining a 'steppe' species, and this is explained by the theory that though there is a steppe vegetation (i.e. definable ecological associations which can be grouped into a steppe formation), there is no steppe flora mainly composed of species limited to this formation. Prof. Stoyanoff (1926) has shown clearly that most of the species characteristic of the North Bulgarian steppes have their centres of distribution and the centres of development of their genera or sections of genera in the Mediterranean Region, especially in the eastern Mediterranean Basin or the Orient, as I have defined these terms. An analysis of the richer and more typical steppe vegetation of the Dobruja leads to similar conclusions.

It is not necessary to deal here with the Hungarian and South Russian steppes except to remark that the species of the former must have very largely entered from the south, that is from the Balkan Peninsula, into their present habitats. The steppe vegetation in the northern parts of the Balkan Peninsula and in Hungary, and possibly also in southern Russia, owes its origin to the selective influence of climatic and edaphic factors on species invading from various formations from various directions, but especially from the south. Plants characteristic of the steppe vegetation in North Bulgaria and the Dobruja but not, even in the Balkan Peninsula, by any means ecologically limited to it, are *Stipa capillata* L., *S. lessingiana* Trin. et Rupr., *S. pennata* Steven, *Chrysopogon gryllus* Trin., *Andropogon ischaemum* L., *Paeonia peregrina* Mill., *P. tenuifolia* L., *Adonis vernalis* L., and numerous species of *Verbascum*, *Umbelliferae*, and thistle-like *Compositae*. The list of species found in the steppe vegetation is a long one and by no means consists mainly of grasses. Yet in numbers of individuals the *Gramineae* predominate over any other family. The steppe vegetation is frequently broken by shiblyak or pseudomacchie brushwood. In spring a host of geophytes flower, especially bulbous species of *Liliaceae*, but by midsummer the steppe vegetation is mostly dry and pale brown in

colour. The greater part of Roumania does not come within our boundaries, but it is interesting to note that the steppe vegetation decreases in richness from the east to the west. Thus, in Roumania, *Astragalus dasyanthus* Pall., *Seseli campestre* Besser, and *Goniolimon besserianum* Nyman are limited to the steppe areas of Moldavia and the Dobruja. The following plants occur in the Dobrujan steppes but do not cross the Danube into Moldavia or Wallachia: *Elymus sabulosus* Bieb., *Allium margaritaceum* S. et S. var. *guttatum* Gay, *Gypsophila scorzonerifolia* Ser., *G. glomerata* Pall., *Onobrychis gracilis* Besser, *Astrodaucus bessarabicus* Drude, *Limonium latifolium* O. Kuntze, *Tournefortia sibirica* L., *Stachys angustifolia* Bieb., *S. sideritoides* Koch, *Phlomis pungens* Willd., *Artemisia arenaria* DC., *Centaurea oviceps* Bornm. and *Tragopogon floccosus* W. et K.

THE HERBACEOUS VEGETATION OF STONY GROUND.

Much high wood, and even brushwood, has been destroyed in the different districts of the Balkan Peninsula, and especially in those of the Mediterranean and transitional parts, leading to partial denudation through a loss of much of the soil covering. The more soluble components and the finer particles of the soil are the first to be lost, and a stony, often shallow, soil results, sometimes passing into bare rock or with bare rock patches at intervals. Frequently the higher mountain zones are either nearly bare rock or have vegetation of a moor or grassland type, while the valleys and lowlands are covered with silt and alluvium. It follows that stony places are especially characteristic of the montane and hill zones, and since these occupy great areas in the Balkan Peninsula, such habitats are very common. In the Mediterranean domain *Pinus halepensis* woods, macchie, and especially phrygana are developed on relatively stony ground, whilst pseudomacchie and phrygana are common in the transitional parts on the same general type of terrain. In the Central European domain these plant communities do not occur or are very rare, and even in the Mediterranean domain and in the transitional districts they by no means account for all the vegetation on a stony substratum. The terms 'Felsheiden' (Felsenheide), 'Felstriften' (Felsentrifte), and 'Karstheide' have been employed by various authors writing in German for the kinds of vegetation included under the present heading.

Rikli (1915) describes the brilliant but short-lived vegetation of the Cretan 'Felstriften' which is in full development at the beginning of May. Conspicuous species are: *Ranunculus asiaticus* L., *Lloydia graeca* L., *Bellis annua* L., *Anthemis chia* L., *Chrysanthemum myconis* L., *C. segetum* L., *Asphodeline lutea* L., *Calendula arvensis* L., *Papaver rhoeas* L., *Matthiola tricuspidata* L., *Iris sisyrinchium* L.,

Anchusa italica Retz., and *Echium elegans* Lehm. Vierhapper (1916) gives a long list of species occurring in 'Felstrift' in Crete, but it is evident that he uses the term in a broader sense than Rikli.

In many parts of South Macedonia on hill slopes, in places where pseudomacchie and phrygana are absent, herbaceous vegetation of a loose open type is common. In the spring numerous geophytic plants of the genera *Ornithogalum*, *Scilla*, *Gagea*, *Romulea*, *Crocus*, and *Muscari* make a gay show of flowers. Later various grasses, *Leguminosae*, *Cruciferae*, *Ranunculaceae*, and *Caryophyllaceae*, are particularly abundant. In the summer *Labiatae*, *Compositae* (especially thistle-like species), and species of *Verbascum* include the chief flowering plants. It is noteworthy that the dry stony habitats are especially favoured by species of the largest genera in the flora of the Balkan Peninsula, such as *Centaurea*, *Dianthus*, *Silene*, and *Verbascum*. Species of the last genus with tall stiff inflorescences and infructescences and white-tomentose leaves and stems were very conspicuous in the summer of 1917 on the southern slopes of the Krusa Balkan after most of the vegetation had withered under the summer heat.

In Serbia and Bulgaria very large areas of stony ground are covered with an open herbaceous vegetation. Lists of species would be very long, but summarizing observations made around Belgrade, Nish, Sičevo, Dragoman, the Liulin Planina, and the Vitoša foot-hills the following genera are characteristic: *Xeranthemum*, *Berteroa*, *Achillea*, *Dianthus*, *Centaurea*, *Verbascum*, *Teucrium*, *Veronica*, *Alyssum*, *Marrubium*, *Euphorbia*, *Vicia*, *Trifolium*, *Festuca*, *Andropogon* (sensu lato), *Anthemis*, *Koeleria*, *Anchusa*, *Thesium*, *Kohlrauschia*, *Delphinium*, *Ranunculus*, *Echinops*, *Allium*, *Melica*, *Satureia*, *Carlina*, *Scolymus*, *Aethionema*, *Onosma*, *Hedraeanthus*, *Asphodelus*, *Helleborus*, *Silene*, *Eryngium*, *Linaria*, *Micromeria*, *Cirsium*, and *Convolvulus*.

The so-called 'Felsentriften' of Dalmatia constitute a large part of the vegetation. The climate is Mediterranean and the plants are mostly geophytes, flowering in the spring and early summer, or have a xeromorphic structure of the aerial parts. Much of the vegetation may be a further stage in the degeneration of macchie and pseudomacchie. The 'Felsenheiden' are typically developed near Dubrovnik. In the spring species of *Romulea*, *Colchicum*, *Ornithogalum*, *Anemone*, *Crocus*, *Muscari*, *Iris*, and *Helianthemum* flower, followed by species of *Bromus*, *Stipa*, *Briza*, *Polygala*, *Aethionema*, *Thymus*, *Asphodelus*, *Dianthus*, *Euphorbia*, *Hedraeanthus*, *Salvia*, *Campanula*, *Allium*, and *Convolvulus*. In the summer the xeromorphic structure of the vegetation is very striking. Densely hairy species of *Inula*, *Stachys*, *Phlomis*, *Marrubium*, *Helichrysum*, *Verbascum*, and *Origanum*, tall *Umbelliferae* (*Opopanax chironium* Koch, *Prangos ferulacea* Lindl., and *Ferulago*

galbanifera Koch), prickly species of *Eryngium* and *Echinops*, aromatic *Labiatae* (as *Micromeria juliana* Benth.), and xerophytic grasses (*Andropogon ischaemum* L. and *Chrysopogon gryllus* Trin.) abound. The beautiful white-leaved *Inula verbascifolia* Hausskn. is especially characteristic.

In the karst areas from Istria to Montenegro stony habitats are most common. Where forest and brushwood have been destroyed the open type of stony or rocky ground vegetation predominates. It is often impossible to draw any sharp line between the vegetation of stony ground and that growing in clefts and joints of the exposed limestone rock. The herbaceous vegetation is most luxuriant in spring and early summer, but as a whole even in summer is much less xeromorphic than the 'Felsentriften' of Dalmatia. The lists of species for different localities are again long ones and it will suffice to mention a number of plants very characteristic for the Istrian karst which I have studied several times. Of the grasses *Andropogon ischaemum* L., *Chrysopogon gryllus* Trin., *Stipa pennata* Stev., and species of *Bromus*, *Sesleria*, and *Briza* are noteworthy. *Labiatae* are abundant, *Teucrium polium* L., *Marrubium incanum* Desr., *Thymus* spp., and *Satureia* spp. being very common. Many bulbous and other geophytic plants flower in the spring, and species of *Asphodelus*, *Asphodeline*, *Anthericum*, and *Allium* flower during the summer. Species of *Silene*, *Dianthus*, *Cyclamen*, *Bupleurum*, *Eryngium*, *Euphorbia*, *Ranunculus*, *Helianthemum*, *Medicago*, *Trifolium*, *Centaurea*, *Verbascum*, *Cirsium*, *Eryngium*, *Carlina*, *Hieracium*, *Linaria*, *Veronica*, *Stachys*, *Salvia*, *Onosma*, *Campanula*, *Helleborus*, *Anemone*, *Thlaspi*, *Peucedanum*, *Potentilla*, *Knautia*, *Scabiosa*, and *Crepis* abound.

THE VEGETATION OF ROCKS.

The vegetation of rocky coasts has been dealt with under the maritime formations. In inland districts it is frequently impossible to draw a sharp distinction between stony and rocky habitats. This is especially true of the karst lands and of the higher mountain zones. Nevertheless much steep solid rock is exposed in many parts of the Balkan Peninsula, and plants inhabiting the cracks and joints are important in helping to weather the rocks to soil. A special vegetation, if not a special flora, initiates a succession which would often proceed even to high forest but for man's interference. On vertical or almost vertical slopes the rock vegetation represents a subclimax unable to proceed to a climatic climax because of physical conditions. In the higher mountain zones high forest is, of course, physically impossible, and it is usually the angle of slope, the nature of the rock, and the local position relative to streams which determine the exposure of solid rock.

In Crete a rich rock (Barranco) flora is developed in damp gorges. Rikli (1915) mentions the following as especially characteristic of the Nibros gorge: *Linum arboreum* L., *Staehelina* sp., *Ebenus cretica* L., *Psilostemon creticum* Willd., *Petromarula pinnata* L., *Verbascum spinosum* L., *Delphinium staphysagria* L., *Tulipa saxatilis* Sieber, *Lloydia graeca* L., *Celsia arcturus* L., *Scrophularia lucida* L., *Brassica cretica* Lam., *Erysimum raulinii* Boiss., *Centaurea argentea* L., *Asphodeline lutea* L., *Arabis verna* L., *Cyclamen repandum* Sibth., *Geranium lucidum* L., *Silene cretica* L., *Saxifraga chrysosplenifolia* Boiss., and *Laurentia tenella* A. DC. A few trees even appear in the rock clefts, as: *Anagyris foetida* L., *Cupressus sempervirens* L., *Quercus lanuginosa* Thuill., *Q. coccifera* L., and *Acer creticum* L. The flora is a very rich and varied one, contrasting in this respect with the phrygana flora. Many endemics are found, a few of which are included in the above list.

In Greece the rocky slopes and peaks are most often calcareous and form the richest habitats for endemic species. For Attica Heldreich (1878) gives the following as the principal species: *Medicago arborea* L., *Lotus creticus* L., *Coronilla emeroides* Boiss. et Sprun., *C. glauca* L., *Pistacia terebinthus* L., *Euphorbia dendroides* L., *Silene spinescens* S. et S., *Brassica cretica* Lam., *Alyssum saxatile* L., *Carum multiflorum* Boiss., *Scrophularia heterophylla* Willd., *Onosma frutescens* Lam., *Teucrium divaricatum* Sieber, *Campanula celsii* DC., *Inula attica* Hal., *Chamaepeuce mutica* DC., *Scorzonera crocifolia* S. et S., *Centranthus ruber* L. var. *sibthorpii* Baldacci, *Ficus carica* L., *Ephedra campylopoda* C. A. Mey., *Oryzopsis miliacea* Aschers. et Schweinf., *Melica ciliata* L., and *M. minuta* L.

In Bulgaria, Macedonia, and Serbia in the hill and montane zones rock exposures are frequent. It is equally true of these districts as of those farther south that the rocky habitats are very rich in endemic species. Thus the endemic *Gesneriaceae* (*Haberlea* and *Ramondia*) are typical rock plants especially flourishing in shady situations, and numerous species of *Sedum*, *Sempervivum*, and *Saxifraga* have the same habitat preferences. Amongst plants normally found on the sunny sides of rock exposures are: *Inula aschersoniana* Janka, *I. macedonica* Hausskn., *Diosphaera rumeliana* Bornm., *Asyneuma limonifolia* Janchen, *Euphorbia myrsinites* L., and various species of *Verbascum*, *Festuca*, *Melica*, *Thymus*, *Hieracium*, *Dianthus*, *Satureia*, *Micromeria*, and *Asperula*.

In the central Rodope, between Buju and Daridere in the oak-zone (700-500 m.), I collected from crevices in metamorphic acid rocks *Sedum hispanicum* L., *S. album* L., *S. sexangulare* L., *Hypericum rhodopeum* Friv., *H. degenii* Bornm., *Orobanche pancicii* G. Beck, *Satureia montana* L. var., *Linum catharticum* L., and a new species of

Dianthus. From the limestone rocks of the mountain above Bačkova, in the northern Rodopes, the following interesting species were added: *Diosphaera rumeliana* Bornm., *Dianthus petraeus* W. et K., *D. frivaldskyanus* Boiss., *Linum rhodopeum* Vel., *Inula aschersoniana* Janka, *Scabiosa rhodopensis* Stoy. et Steff., *Haberlea rhodopensis* Friv., *Centaurea sublanta* Boiss., *Saxifraga porophylla* Bertol., *S. aizoon* Jacq., and *Carum graecum* Boiss. et Heldr. On the rocky and stony slopes of the Karlik Dagh on the Bulgarian and Thracian border the plants I collected from the rock-crevices, though they were not always confined to this habitat, included *Rosa spinosissima* L., *R. tomentosa* Sm., *Anthemis montana* L., *Campanula moesiaca* L., *Genista carinalis* Griseb., *G. rumelica* Vel., *Silene waldsteinii* Griseb., *Asperula* spp., *Veronica spicata L.* var. *latifolia* Turrill, *Sempervivum patens* Griseb., *S. ruthenicum* Koch, *Waldsteinia geoides* Willd., *Sedum maximum* Suter, and *Hypericum olympicum* L. On the slopes of the Rila valley, in the beech and conifer woods, I was impressed by the occurrence of large rock exposures, especially in places where in past years avalanches of winter snow had cleared away trees and soil. Often the rocks formed steep cliffs and had an open vegetation, floristically and ecologically very different from that of the surrounding forest. Between 1,450 and 1,550 m. on rocks we found *Minuartia saxifraga* Graebn., *Scrophularia aestivalis* Griseb., *Symphyandra wanneri* Heuff., *Sempervivum patens* Griseb., *S. blandum* Schott, *Gentiana lutea* L. subsp. *symphyandra* Murbeck, *Coronilla varia* L., *Verbascum jankaeanum* Panč., *V. balcanicum* Vel., *Onosma tubiflorum* Vel., and several species of *Sedum*. Near Čamkorija in fir forest the same phenomenon of exposed rocks occurs, with *Silene lerchenfeldiana* Baumg., *Sempervivum patens* Griseb., *Linaria dalmatica* Mill., and a few other species.

Around Dubrovnik in southern Dalmatia there is much exposed limestone rock which merges gradually into stony habitats. In the summer of 1925 I studied this in numerous localities. Many of the plants were in fruit, but a considerable number were flowering freely in spite of the heat and drought. In addition to dwarfed examples of macchia shrubs (*Juniperus oxycedrus* L., *Pistacia lentiscus* L.) the following in flower or fruit were conspicuous: *Inula verbascifolia* Hausskn., *Putoria calabrica* L., *Ruta divaricata* Ten., *Campanula pyramidalis* L., *Foeniculum vulgare* Mill., *Capparis rupestris* S. et S., and *Thelygonum cynocrambe* L. A considerable number of grasses were collected in fruit and *Andropogon ischaemum* L. in full flower. Around the Bocche di Cattaro blue, white, and lilac flowered varieties of *Vitex agnus-castus* L. and clumps of *Ailanthus altissima* Swingle flourished in the rock clefts and stony ground. In the karst country of the north-west of the Balkan Peninsula the rock vegetation is an im-

portant element, though many of the species occur also in stony habitats and the number of endemics is less than in similar habitats farther south.

In Istria and Montenegro, where I have most studied true karst vegetation, exposed rocks occur on hill and mountain slopes and escarpments, forming the sides of some dolines, and as flat limestone pavements. As an example of the first the rocky peak of Mt. Maggiore (1,396 m.) may be taken. The beech forest reaches nearly to the top, the trees dwarfing considerably. The peak is of nearly bare limestone, but the following plants may be found in the clefts: *Cerastium arvense* L. var., *Silene saxifraga* L., *Arabis alpina* L., *A. scopoliana* Boiss., *Kernera saxatilis* Reichb., *Saxifraga aizoon* Jacq., *Globularia bellidifolia* Ten., *Micromeria thymifolia* (Scop.), *Senecio nebrodensis* L., *S. abrotanifolius* L., *Galium purpureum* L., *Scrophularia laciniata* W. et K., *Rosa pendulina* L., and *Sesleria tenuifolia* Schrad. The dolines so characteristic of the karst are of many sizes, shapes, and degrees of steepness. They vary consequently as to the nature of the sides and the vegetation clothing them. When the sides are steep and rocky, trees and shrubs of the karst wood and brushwood associations may occur in the clefts. Thus *Quercus lanuginosa* Thuill., *Juniperus communis* L., *Corylus avellana* L., *Carpinus orientalis* Mill., *Cornus sanguinea* L., and *Crataegus monogyna* Jacq. are some of the trees and shrubs I have noted on the sides of rocky dolines. Numerous plants of the karst heath occur where the woody vegetation is absent. Expanses of limestone pavement, often with widened and deepened joints, are very frequent in the karst country. Low bushes of *Juniperus communis* L., *Cotinus coggygria* Scop., and *Rhamnus* spp., with *Sedum* spp., *Tunica saxifraga* Scop., *Cyclamen europaeum* L., *Andropogon ischaemum* L., *Anthericum liliago* L., and *Satureia* sp. occupy the cracks where earth has accumulated.

In the high mountain zones steep rock exposures are frequent and form habitats for many rare and endemic plants. The vegetation and flora vary with the exposure and with the chemical and physical structure of the rock, more especially with the calcareous and non-calcareous nature of the strata. This is especially noticeable in the central parts of the Balkan Peninsula, where calcareous, igneous, and metamorphic rocks occur often in the same mountain massif. The total flora of rocky places in the high mountain zones is very large, and it will be sufficient here to deal with a few definite examples. The Suva Planina ('dry range') only just reaches to the second high mountain zone and is built of limestones. Interesting constituents of the rock flora near the highest peaks are: *Veronica bellidioides* L., *Saxifraga marginata* Sternb., *Carex sempervirens* Vill., *Androsace villosa* L., *Poa*

violacea Bellardi, *Potentilla apennina* Ten., *Viola grisebachiana* Vis., and *Erysimum comatum* Panč. The Vitoša is mainly composed of acid igneous rocks, and on part of the high northern slope great boulders are piled on one another with scarcely any foothold for plants. Above this area the outcrop of bare rock is not so abundant as on many mountains, but sufficient occurs for species of *Saxifraga*, *Sedum*, and *Sempervivum* to form a vegetation in the cracks, though most of the rock vegetation here is cryptogamic.

The rocky peaks of the Rila Dagh are the home of many high-mountain species, including interesting endemics. While there are now no permanent glaciers, large and small patches of snow were much in evidence in July 1926, when I climbed Musalla, and the wind was bitterly cold. Between the corrie lakes and the topmost peak the following plants growing in rock-crevices were collected: *Geum bulgaricum* Panč., *Polygonum alpinum* All., *Gentiana punctata* L., *G. frigida* Haenke, *G. pyrenaica* L., *Scleranthus neglectus* Rochel, *Veronica bellidioides* L., *Aquilegia aurea* Janka, *Dianthus microlepis* Boiss., *Arenaria biflora* L., *Minuartia recurva* Schinz et Thell. var. *orbelica* (Vel.) Stoy. et Steff., *Saxifraga retusa* Gou. var. *baumgartenii* Vel., *S. pedemontana* All. subsp. *cymosa* Engl., *Potentilla ternata* C. Koch, *Senecio carpathicus* Herbich, *S. glaberrimus* Rochel, *Achillea atrata* L. subsp. *multifida* (DC.), *Campanula alpina* Jacq. var. *orbelica* (Panč.) Stoy et Steff., and *Armeria alpina* Willd.

THE VEGETATION OF SANDY HABITATS.

The vegetation of maritime sand-dunes and of sandy sea-shores has already been considered. In many inland parts of the Balkan Peninsula sandy stretches, often of small area, occur in plains, valleys, at the foot of hills and mountains, and in summer in dried up stream-beds. Such habitats may have a vegetation belonging to one or other of the plant communities already mentioned, but many are unstable habitats with a very open varying plant covering. The only extensive stretches of sandy terrain in our area occur along the shores of the Danube main stream in northern Serbia, North Bulgaria, and the Dobruja. Much of this area is covered with an open herbaceous vegetation of a steppe-like nature. Dunes occur in places. The most characteristic plants are *Festuca ovina* L. var., *Polygonum arenarium* W. et K., and *Euphorbia seguieriana* Necker. Numerous other species occur, especially grasses of the genera *Bromus*, *Elymus*, *Cynodon*, *Setaria*, and *Agropyrum*. Species of *Euphorbia* and *Veronica* are also very characteristic. Sand washed down by winter floods may accumulate at the foot of hills and mountains of igneous or metamorphic rock. Near Karamudli, on the southern slopes of the Krusa Balkan, I have dug into such loose sand

Near Mt. Musalla, western Rodope massif. Bogs and boulders in the foreground, consociations of *Pinus montana* at the foot of the higher slopes, and *Juniperus communis* var. *nana* above at about 2,500 m.

In the pass between Čamkorija and Rila, in the western Rodope massif. Scanty vegetation limited to high mountain plants. Photograph taken at over 2,000 m. in August.

to a depth of over two metres. Here an open vegetation was dominated by *Plantago indica* L., *Tragus racemosus* Hall., *Centaurea calcitrapa* L., and *Polygonum pulchellum* Loisel, with species of *Trifolium* and *Medicago*. Many of the streams in the Mediterranean and transitional parts of the Balkan Peninsula dry up in the summer, or have only a small trickle of water. Often these streams are in deep ravines, or 'nullahs', for part of their courses. Patches and stretches of sandy ground then alternate with stones and rocks and have an open type of vegetation. In such sandy places in dried up river beds in South Macedonia I have noted as particularly characteristic: *Chenopodium botrys* L., *Trifolium fragiferum* L., *T. hybridum* L., *Melilotus alba* Desr., *Galega officinalis* L., and *Portulaca oleracea* L. In August 1926 I examined the junction, at 300 m. altitude, of the Rilski and Struma rivers in western Bulgaria. These rivers have jointly formed a flat area with considerable patches of pure sand. The vegetation was very open, with *Cynodon dactylon* Pers. dominant and *Cichorium intybus* L., *Linaria genistifolia* Mill., and *Tunica saxifraga* Scop. occurring here and there.

The weed flora of sandy fields around Varna is of considerable interest. In August 1926, to the north of the town, some such fields had their crops and all other weeds smothered by *Plantago indica* L. To the south of Varna characteristic summer flowering weeds of fields on sandy soil were: *Rumex acetosella* L. var. *multifidus* DC., *Agrostemma githago* L., *Delphinium paniculatum* Host, *Orlaya grandiflora* L., *Legousia speculum-veneris* Fisch., and *Filago arvensis* L. In a field with similar soil, but lying fallow, we noticed as especially abundant: *Cynodon dactylon* Pers., *Mentha microphylla* Koch, *Chondrilla intybus* L. var. *glabratum* Presl, and a few plants of *Xanthium spinosum* L. On a long sandy slope without brushwood, and possibly representing an old field, which had not, however, been in use for many years, the flora was very rich and included *Lepidotrichum uechtritzianum* Vel., *Xeranthemum annuum* L., *Plantago indica* L., *Artemisia campestris* L. var. *sericea* Koch, *Teucrium polium* L., *Linaria euxina* Vel., *Herniaria glabra* L., *Chondrilla juncea* L., *Eryngium campestre* L., *Scabiosa ucranica* L., *Centaurea sterilis* Steven, *Verbascum glanduliferum* Vel., *Jasione heldreichii* Boiss. et Orph. var. *microcephala* Vel., *Tragus racemosus* Hall., *Helichrysum arenarium* DC., *Achillea compacta* Willd., *Anchusa officinalis* L., and *Anthemis tinctoria* L.

SOILS AND VEGETATION.

Ecologically and phytogeographically the most important original factor in the Balkan Peninsula is climate, but it is of considerable interest to consider the effect of soil, within our area, both as modifying the flora and vegetation and for comparison with the edaphic factors

under other climatic conditions. In the Balkan Peninsula, as in other parts of Europe, the greatest contrast in edaphic conditions is between calcareous and acid or neutral soils, though in some of the western parts a marked difference in the vegetation on serpentine and non-serpentine rocks is noticeable. Edaphic factors, whether directly chemical or physical or indirectly biotic through the actions of soil organisms, are most certainly secondary to climatic factors, as is made clearer by a consideration of the general as well as the Balkan Peninsular distribution of some non-endemic species. It is a well-known fact that many relatively southern species, reaching their northern limit in North-west Europe, occur there only on chalk or limestone, or at least reach their maximum development, as individuals or as dominants in plant communities, on soils derived from calcareous substrata. A number of these same species reach their southern limit in the Balkan Peninsula and there appear either indifferent to the kind of soil or are absent from those soils with a high percentage of calcium carbonate. Conversely, there are many species which are southern in their distribution relative to the Balkan Peninsula, and only penetrate inland from the south or east to reach their northern limits on calcareous strata. Thus, both in North-west Europe and in the Balkan Peninsula many southern species occur at their northern limits only or chiefly on calcareous soils, but the species are quite different.

We will consider first some woody plants whose natural soil requirements are, in varying degrees, different in the Balkan Peninsula, and north-western Europe.

Fagus silvatica L. is a characteristic tree of the montane and, sometimes, of the lowest high mountain zones of the central, northern, and north-western parts of the Balkan Peninsula. Its lower and upper limits are often very clearly defined at approximately 700 m. and 1,700 m. respectively. While it tends to occupy the most humid zone, it is usually indifferent to soil conditions, and occurs on all kinds of igneous, metamorphic, and sedimentary substrata. In Istria it shows some preference for limestone, but this may be due to the fact that most of the higher ground is there composed of this rock. In Albania it is said to make stronger growth on limestone than on serpentine. In Serbia, Bulgaria, and the Rodopes I have also noted that where the substratum is limestone and the beech and conifers occur together the former tends to extend at the expense of the latter. On limestone the beech trees are not larger or of better tone than they are on other kinds of rocks; indeed, the finest individual trees of the species I have seen were on metamorphic substrata in the Rila valley in August 1926. On limestone the power of multiplication, and especially of rejuvenation after forest felling, is much greater in the beech than in the coni-

fers. The beech has a great power of developing dormant or adventitious buds, which from stumps and broken branches form a dense brushwood long before conifer seedlings can become established. A similar power of rejuvenation is absent from the Balkan Peninsular *Pinaceae*. On non-calcareous rocks the beech is usually dominated by the pines, fir, and spruce, where they occur together, and the latter retain their dominance, unless very ruthlessly destroyed by man. There are, however, exceptions to this. Thus on the Belasitsa Planina the beech forms a complete zone up to the tree limit, but in Ali Botuš it is nearly limited to an area of schists and gneisses on one side of the mountain, the limestone of the rest of which is covered with coniferous forests. In eastern Bulgaria the common beech is absent, but *Fagus orientalis* Lipsky occurs at lower altitudes on both limestones and metamorphic strata. The two species meet in the south-eastern Rodopes, near Daridere, where in July 1926 we found the common beech abundant on the higher hills and the oriental beech in a sheltered low-lying valley from 800 to 550 m. altitude.

Taxus baccata L. is known from most of the central districts of the Balkan Peninsula and extends south to Greece and Thessaly. In Bulgaria it is rare, but is known from the Rila, Central Stara Planina, Rodope, Vitoša, Ali Botuš, Belasitsa, and Strandja. It occurs on both calcareous and non-calcareous rocks, but always under edaphically wet and atmospherically moist conditions, as near streams and waterfalls. In the western parts of the Balkan Peninsula it flourishes on limestone under drier conditions. *Fraxinus excelsior* L. is known from most of the districts north of Epirus, Aetolia, and Thessaly inclusive. It occurs chiefly between 200 and 1,200 m. on various kinds of soil and rock. In the eastern part of Bulgaria and in the Dobruja *F. pallisae* Wilmott is endemic, so far as is known. The occurrences in eastern Bulgaria of another ash and of another beech different from the common European and Balkan Peninsular species is noteworthy. *Clematis vitalba* L. is widely distributed within the Balkan Peninsula, where it is found in relatively dry places and, even more luxuriantly, near streams, in woods and brushwoods, up to the montane zone, and on various types of soil, but especially on those derived from rocks of igneous and metamorphic origin. *Buxus sempervirens* L. is recorded only from Euboea, Thessaly, Epirus, Albania, Macedonia, Thrace, and doubtfully from Dalmatia. It is most frequent on serpentine and, in Northern Albania at least, definitely avoids limestones according to Košanin. On the Thessalian Olympus it ascends to 2,000 m. *Viburnum lantana* L., *Juniperus communis* L., and *J. oxycedrus* L. are apparently indifferent to the chemical nature of the soil in our area, but *J. macrocarpa* S. et S. is usually, and in the north-west entirely, limited to calcareous strata.

The penetration in the lowlands and up the river valleys of species whose main distribution is in the Mediterranean domain is characteristic of many parts of the Balkan Peninsula. Quite frequently isolated enclaves of Mediterranean species occur in far inland districts, and these are usually on limestone. Thus in the Nishava area many Mediterranean species occur on limestone, including: *Muscari pulchellum* Heldr. et Sart., *Nigella damascena* L., *Aethionema graecum* Boiss. et Heldr., *Euphorbia myrsinites* L., *Convolvulus hirsutus* Steven, *Echium italicum* L., *Lithospermum apulum* Vahl, *Salvia argentea* L., and *Scutellaria albida* L. Similar enclaves rich in southern types and in endemics occur in the Rodopes. For example, above Bačkova a limestone mountain rises to 1,600 m. It is very dry and its slopes were covered with mixed conifer and broad-leaved woods in which exploitation had just begun in July 1926. In rocky and open places the following essentially Mediterranean or Pontic species occurred: *Juniperus oxycedrus* L., *Aristolochia clematitis* L., *Saponaria glutinosa* M.B., *Silene compacta* Fisch., *Carum graecum* Boiss. et Heldr., *Morina persica* L., and *Ajuga laxmannii* Benth. I also collected the following endemics: *Saxifraga stribrnyi* Vel., *Haberlea rhodopensis* Friv., *Scabiosa rhodopensis* Stoy. et Stef., and *Diosphaera rumeliana* Bornm. Although the primary factor in the distribution of Mediterranean species and vegetation is undoubtedly climate, the predominance of limestone is probably an important secondary cause for their extension far up the Adriatic, even to Istria.

In Istria, where there is much alternation of calcareous and arenaceous strata, the limitation of species to one or other type of soil is a prominent feature of the vegetation. The following species, amongst many others, as a rule occur only on calcareous soil and often almost directly on the karst limestone: *Sesleria tenuifolia* Schrad., *Gagea pusilla* R. et S., *Veratrum nigrum* L., *Drypis spinosa* L., *Moehringia tommasinii* Marchesetti, *Silene otites* Wibel, *Delphinium fissum* W. et K., *Ranunculus illyricus* L., *Coronilla vaginalis* Lam., *Rhamnus catharticus* L., *Phillyrea latifolia* L., *P. media* L., *Euphorbia tommasiniana* Bert., *Myrtus communis* L., *Opopanax chironium* Koch, *Salvia officinalis* L., *Satureia subspicata* Bartl., *Teucrium polium* L., *Digitalis laevigata* W. et K., *Verbascum lychnitis* L., *Hedraeanthus tenuifolius* DC., *Echinops ritro* L., *Hieracium hoppeanum* Schultes, and *Jurinea mollis* L. It is interesting to note that some of these plants, such as *Teucrium polium*, in districts farther south, as in South Macedonia and the Rodopes, occur on non-calcareous soils at least as abundantly as on calcareous.

Another characteristic of calcareous substrata is that they frequently serve as refuges for relict species. Thus all of the *Gesneriaceae* of the

Balkan Peninsula occur on limestones, though not entirely limited to them. On the dry limestone hills above Dragoman I have collected *Prunus nanus* Stokes, *A. wilmottianus* Stoy., *A. depressus* L., *A. pubiflorus* DC., *Cachrys alpina* MB., *Eryngium palmatum* Panč. et Vis., *Hyssopus officinalis* L., *Goniolimon tataricum* Boiss., *Artemisia alba* Turra, *Jurinea tsar-ferdinandii* Davidoff, and other species which are here of relict nature.

A very striking exception to the general rule is, however, provided by *Forsythia europaea* Degen et Baldacci, a Tertiary relict which is known only from Albania and Novi Pazar. The species is absolutely limited to serpentine and diorite substrata. Even where it occurs on the boundary between serpentine and limestone it never gets on to the latter. Košanin (1913) suggests that under the existing climatic conditions it cannot withstand competition with the many other trees and shrubs on the limestone. Even on the serpentine the *Forsythia* prefers places where the woody vegetation is open, as on stony or bare ground. It is a light-loving plant and dies in the shade.

The significance of the facts mentioned above is emphasized by the collections of Stoyanoff and Stefanoff (1922) in the Pirin mountain mass to the south-west of the Rodope. Comparing the oreophytic vegetation on calcareous and siliceous substrata, the following facts emerge: (1) There is a greater percentage of xerophytes on the limestone. (2) The percentage of chamaephytes in the whole vegetation is 50 per cent. on calcareous and 21 per cent. on siliceous terrain, the chamaephytes especially replacing hemicryptophytes on the former. (3) Southern species are more strongly represented on the limestone. (4) The vegetation is richer in species on the calcareous substratum. (5) Endemics are more numerous in the limestone areas. (6) The steppe elements are less characteristic on the siliceous than on the calareous soils and rocks. (7) The generic coefficient (*sensu* Jaccard), that is the average ratio of genera to 100 species, is higher on the limestone than on the granite.

Practically no detailed work on the soils of the Balkan Peninsula relative to the vegetative covering has been done by modern ecological methods. Sufficient, however, is known to make it obvious that there is here a field of research of a very interesting nature, especially if it is investigated in such a manner as to allow of comparison with edaphic conditions in Central and Atlantic Europe.

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IX

PLANT SUCCESSION

General. It is not yet possible to give anything approaching a full account of the processes and stages of plant succession in the Balkan Peninsula. It is obvious that much more detailed ecological research must first be done by resident botanists before sufficient data are available for more than an incomplete sketch. The following synoptical account is almost entirely based on my own limited observations, and I have had no opportunity for making field experiments in the Peninsula. Nevertheless it is desirable to give the facts collected so far, since one object of the present work is to direct attention to important lines of botanical research for future workers on the flora and vegetation of our area.

There is no doubt that the fundamental principles of plant succession hold for the Balkan Peninsula, but I am not prepared to accept all of Clements's conceptions as published in his *Plant Succession*, nor, probably owing in part to lack of sufficient data, can I always apply his nomenclature. It is generally accepted that climatic factors are, at least in taking a world-wide view of vegetation, of first importance as directional and limiting causes of plant succession. Thus Clements allows only the climatic climax. Tansley and Chipp (*Aims and methods in the study of vegetation*, London, 1926, p. 9) consider in addition an edaphic climax. If the use of the term climax is to be extended at all beyond the climatic climax, it would be most logical to use it for the relatively final type of vegetation developing in any area, and to designate a climatic, edaphic, or biotic climax according as the actual factors preventing any further development are climatic, edaphic, or biotic, thus raising the subclimaxes of Clements to the value of climaxes. There is, however, another aspect of plant succession which seems to have been very largely ignored,[1] or, perhaps, has been tacitly assumed to be fundamental but not the immediate concern of ecology. This may be termed the phytogeographic, and is well illustrated by sclerophyllous communities. Thus in the Mediterranean domain of the Balkan Peninsula we have seen that macchie are common and characteristic. In California the chaparrals are from the ecological standpoint very similar to the macchie, and are developed under very similar climatic conditions.[2] Yet the species, and in large part the

[1] See, however, Moss, in *New Phyt.* ix. 43 (1910).

[2] See W. S. Cooper, *The Broad-sclerophyll Vegetation of California*, 1922.

genera, are quite different. Other types of sclerophyllous vegetation, ecologically similar but floristically distinct, are found in other parts of the world where a 'Mediterranean' climate occurs. This is but one illustration of what may, perhaps, be regarded as a truism, that any and every plant community of the existing vegetation is phytogeographically limited both as to what it includes and as to what it excludes. At any given time and in any given area only certain species are available as constituents of any plant community. This is obvious if the selecting power of the environment alone be accepted, and even if the environmental factors directly cause specific changes they could only act on species actually present. There is no need to labour the point that this phytogeographical limitation has been a factor in past geological successions as well as in the seres whose stages can now be studied. Light can be thrown on the origin and development of vegetational communities by phytogeographical studies even as the genetics and evolution of species and other taxonomic units can only be understood after reference to distribution.

For the Balkan Peninsula the phytogeographic limitations of plant succession may be regarded as due essentially to the differentiation of a relatively uniform early and middle Tertiary North Temperate flora corresponding with the differentiation of a relatively uniform warm temperate climate. This differentiation reached a climax in the Ice Age, but the Balkan Peninsula was less affected by the Ice Age itself than were most other parts of Europe (excepting the Iberian and Italian peninsulas), and probably the climax communities now found there are older as such and have had a more stable history than any others in Europe. With this development *in situ* have been associated modifying 'immigrations' and 'emigrations' of which one extending from the east in a westerly and north-westerly direction is probably the most important.

The phytogeographic aspect of plant succession has been purposely emphasized in the above introductory paragraphs partly because this work is essentially a phytogeographical study and partly because the plant communities of the Balkan Peninsula clearly illustrate the general principles just indicated.

In attempting to give an outline of plant succession in the Balkan Peninsula the sequence followed in describing the plant communities will be adopted and a general summary will be given at the end.

MARITIME COMMUNITIES

The marine *Potamogetonaceae* occur locally around most of the coasts. In the northern Adriatic *Zostera* especially forms dense socies to within a short distance of the land. Probably these in time change through

silting into narrow or broad stony mud flats with *Salicornia*, *Suaeda*, and other halophytes, when a normal progressive sequence is not interfered with by coastal submergence, as on the Dalmatian coasts, or by man, as near Porto Rosa in the north of the Istrian Peninsula, where artificially controlled salt-pans have been formed.

The seres commencing with, or having as one stage of their progression, a coastal community, have relatively little importance in the Balkan Peninsula, partly because of their very local occurrence and partly because from late geologic to recent times submergence and disintegration have been more important than elevation and accretion. With stable physical conditions the seral stages of salt-marshes, sand-dunes, stony beaches, and rocky coasts should form a very interesting contrast in the Central European and Mediterranean domains respectively, especially in their floristic composition. The conditions on the sandy stretches near Varna and Burgas are detailed elsewhere, and at the former place the succession is from dry sand flats and saline pools to grassland whose further development is limited by grazing. Comparison with the hill shiblyak to the south of Varna on sandy soil suggests that the removal of the biotic limiting factor would result in succession through shiblyak to deciduous forest with *Quercus* spp. dominant. On the Adriatic I have only seen slight evidence of the transition from shore communities to macchie, as near Gravosa and Ragusa and again in southern Istria. Judging from remarks made by Baldacci it appears that such succession is better observable in parts of Albania and Epirus.

AQUATIC AND MARSH COMMUNITIES.

My own observations and the few published relevant accounts leave little doubt that the sequence of events in the Balkan Peninsula in the initial stages of succession in hydroseres is very similar to that characteristic of Europe generally. The chief cause of this is that, as in most other parts of the North Temperate Region, the aquatic and marsh floras are dominated by species having a wide general distribution. There are relatively few aquatic and marsh plants endemic to the Balkan Peninsula, though there is a considerable number not yet recorded from more than a few districts within it. The latter, however, nowhere seem to be dominant in successional stages. That within recent geologic times down to the historic period there has been much decrease in the area of freshwater lakes and marshes, especially in the central districts of the Balkan Peninsula, is certain. The natural silting up of lakes can be well studied in the Struma Plain, in Lakes Tahinos and Butkova, and the effects of artificial drainage in Lake Copais and the Dragoman blato. Invasion by tall-

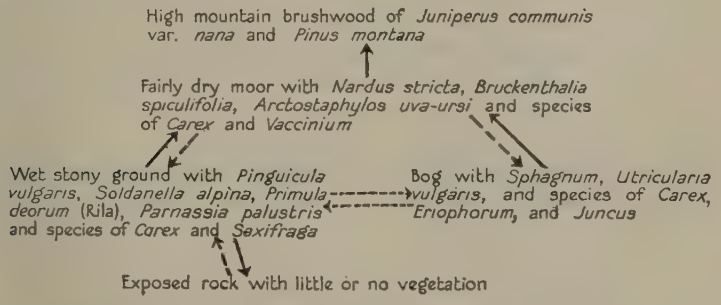
growing marsh plants such as *Phragmites*, *Iris*, *Typha*, *Sparganium*, and *Scirpus*, naturally succeeds the aquatic phase. As a rule nowadays grazing animals, chiefly cattle, are summer-pastured on the drying-up marsh land, and in very dry seasons considerable areas are cut for fodder &c., as I saw near Dragoman in August 1922, or the ground is speedily ploughed for cereals or cotton. Observations in South Macedonia suggested that there a probable natural sequence in the lowland and hill zones was:

	Dominant and characteristic species.
Aquatic communities:	*Algae.* *Potamogeton natans* L., *P. lucens* L. *Ceratophyllum demersum* L., *C. submersum* L. *Lemna minor* L., *L. trisulca* L., *L. gibba* L. *Zannichellia palustris* L. *Myriophyllum verticillatum* L., *M. spicatum* L. *Hydrocharis morsus-ranae* L.
Marsh:	*Scirpus lacuster* L., *S. maritimus* L. *S. holoschoenus* L. *Phragmites communis* Trin. *Phalaris arundinacea* L. *Cyperus longus* L. *Butomus umbellatus* L. *Orchis palustris* Jacq. *Iris pseudacorus* L. *Heleocharis palustris* R. Br. *Lythrum salicaria* L.
Mixed marsh and brushwood:	as above with bushes of *Tamarix tetrandra* Pall. and bushes and small trees of *Salix alba* L.
Shiblyak:	*Paliurus spina-Christi* Mill. (often dominant over large areas). *Jasminum fruticans* L. *Cotinus coggygria* Scop. *Colutea arborescens* L. *Periploca graeca* L.
Deciduous forest:	*Quercus conferta* Kit., *Q. lanuginosa* Thuill. *Ulmus campestris* L.

Very frequently this sequence is interrupted at one of the later stages by the land being put under cultivation.

BOGS AND MOORS.

These are almost or quite limited to high mountain districts and may as such be regarded as climaxes for the climatic conditions prevalent at the given altitudes, except where development into denser and taller brushwood is possible. Any succession in which they partake must have a very small developmental range and be of a very local nature. Usually the vegetation cannot progress beyond the life forms of nanophanerophytes or suffruticose chamaephytes because of climatic limitations. Moreover, there is a considerable amount of what I can only describe as fluctuating succession. Steep slopes, local accumulations of snow, large and small avalanches, and changing watercourses are physical features which intermittently modify areas of varying size, bringing about partial or complete denudation and the initiation of secondary successions. There is little chance of continuous advance over large compact areas from initial to climatic climax stages. It is only locally that bog peat accumulates and, if the altitude is not too high and the exposure not too great, is succeeded finally by low brushwood of *Juniperus communis* L. var. *nana* Loud. or var. *hemisphaerica* Parl. and of *Pinus montana* Mill. Most often small bogs with pools and streamlets alternate with sandy, stony, and rocky patches, and it is clear that the scheme of succeeding stages cannot be represented as taking place in one direction only. The following tentative scheme is based mainly on my observations made in the Vitoša and Rila:


High mountain brushwood of Juniperus communis var. nana and Pinus montana
Fairly dry moor with Nardus stricta, Bruckenthalia spiculifolia, Arctostaphylos uva-ursi and species of Carex and Vaccinium
Wet stony ground with Pinguicula vulgaris, Soldanella alpina, Primula deorum (Rila), Parnassia palustris and species of Carex and Saxifraga
Bog with Sphagnum, Utricularia vulgaris, and species of Carex, Eriophorum, and Juncus
Exposed rock with little or no vegetation

The progression to the climax of brushwood is indicated by solid arrows. This climax is only reached where silting or slope has led to the formation of a fairly dry terrain. At the highest altitudes and in the most exposed situations the brushwood climax is not reached, and one or other of the other lower and more open types of vegetation or exposed rock is alone attained. It is also obvious in the field that the ideal progression is often modified by local changes in topography, such as slipping of screes, avalanches, and alteration of small water-

courses by silting, and sudden or gradual changes in the vegetation may then occur in a reverse direction. These are indicated by dotted arrows.

FORESTS.

The climatic climax for all parts of the Balkan Peninsula is naturally forest, with the following exceptions: (1) high mountain altitudinal zones 5*b* and 5*c*; (2) possibly part of the steppe area of the north-east; and (3) possibly some of the coastal macchia areas. The last two exceptions are doubtful ones and their validity or invalidity can only be determined by further extensive and intensive field study. There is no doubt that trees will grow in some of the steppe areas and also that some of the macchie represent undergrowth of destroyed *Pinus halepensis* forests. On the other hand, some authors have concluded that grassy steppes are naturally the climax under the climatic conditions of the Dobrujan lowlands and in parts of North Bulgaria, while others have urged that Greek and Dalmatian macchie are, partly, natural climax communities and can be distinguished from secondary macchie.

A. **Mediterranean Climatic Domain.**

1. *Coastal Belt* (and sometimes, in the south, the lowland and hill zones).

The climax association is that of *Pinus halepensis* with undergrowth of macchie. In the northern parts of the domain this is restricted to the coast, but in Crete and Greece locally reaches to 800 m. or slightly more. I have studied a few examples of secondary succession in the Lapad Peninsula where transitions from 'Felsenheiden' through macchia to *Pinus halepensis* forest occur. It is not always easy to know whether the series should be read up or down unless tree stumps are visible, and I suspect that in this beautiful area vegetation is not likely to improve with the change in régimes as a result of the war. However, in one area about the middle of the Peninsula it was fairly evident that for several decades sheep and goats had been excluded and natural rejuvenation from scattered stony-ground vegetation to macchie of varying luxuriance, and finally to *Pinus halepensis* forest could be traced. That under the action of man, sheep, and goats high forest gives place to macchie, and these to stony and rocky 'heaths' with a very open vegetation, yet often rich in species, is a familiar fact in Dalmatia, while farther south still in Crete, Greece, and locally in South Macedonia phrygana is the final biotic climax or subclimax.

Pinus pinea can scarcely be considered as forming more than small local societies, with perhaps a few exceptions in Greece.

2. *Lowland and hill zones.*

The climax communities are oak-woods, often with undergrowth approximating to pseudomacchie, laurel-woods, and cypress-woods. On an average they range up to an altitude of 700 to 1,000 m. The dominant species varies locally. Thus consociations of *Quercus conferta* Kit. and *Q. lanuginosa* Thuill. are common throughout the domain and beyond it, while *Q. aegilops* L. is limited to the most southern districts of the Peninsula and entirely to the Mediterranean domain, where it is partly preserved as a woodland dominant because of its value in providing tanning materials. Societies of *Fraxinus excelsior* L. and *Castanea sativa* Mill. also occur in what must be considered oak associations.

The laurel (*Laurus nobilis* L.) can rarely be found dominating a community. The only area I have studied where it occurred relatively pure is in eastern Istria at the base of Mt. Maggiore. Whether it should be accepted as forming in this locality a community distinct from the oak forests or as an extensive local facies (society) of these I am not sure.

In Crete cypress woods (*Cupressus sempervirens* L.) must be considered as a climax community, though they have now been so destroyed that their natural importance is a matter of deduction.

3. *Montane and lowest high mountain zones.*

The climax associations are coniferous forests dominated by *Abies cephalonica* Loud. or *Pinus nigra* Arn., or, in the north, beech forest with *Fagus silvatica* L. dominant. On an average they reach up to 1,500 m. altitude.

Abies cephalonica still forms extensive woods in Greece and north to Epirus, Thessaly, and Macedonia. That this consociation must have been far more extensive before man's exploiting activities commenced is certain, and though in places in the north it is being replaced by beech there is no valid reason for supposing this to be due to secular climatic changes or to the fir woods not being a natural climax, yet neither of these possibilities can be entirely dismissed with our present available knowledge.

Pinus nigra may form consociations within the fir area but it also extends beyond to form communities, often of remarkable purity, within the Mediterranean domain as far north as Dalmatia.

Fagus silvatica only occurs in the northern parts of the Mediterranean domain and in the mountains, where climatic conditions approximate to the Central European type, and it is properly considered below.

B. Areas climatically transitional between the Mediterranean and Central European Domains.

The most extensive climax association is that of the manna-ash and oak woods. These are here considered as forming one association, with *Fraxinus ornus* L. and one or more of the common species of *Quercus*, *Q. conferta* Kit., *Q. lanuginosa* Thuill., *Q. robur* L., and *Q. sessiliflora* Salisb. as co-dominants. Very frequently local consociations cover considerable areas with one species of oak, *Carpinus orientalis* Mill., *Ostrya carpinifolia* Scop., or *Corylus colurna* L. relatively pure. The mixture of species may locally be very great and the subordinate species of the tree layer and the associated shrubs and ground flora vary especially with the phytogeographical position of each area.

The woods of *Fagus orientalis* Lipsky of eastern Bulgaria probably represent a climax association for what may be an area with a 'Pontic' climate, if this is ever separately defined. Certainly the climatic conditions are in many respects intermediate between those of the Mediterranean and Central European domains, and the vegetation likewise contains elements of both, with, however, in the Strandja, a dominance of distinct Pontic species and communities in association with the oriental beech.

In the higher parts of the transitional areas the climax communities are usually the same as for the Central European domain.

C. Central European Climatic Domain.

1. *Lowland and hill zones.*

The oak association is the climax community for the lowland and hill zones of all the central parts of the Balkan Peninsula and reaches an average altitude between 700 and 1,000 m. Often it is divisible into consociations dominated by one or other of the following deciduous species of oak: *Quercus conferta* Kit., *Q. lanuginosa* Thuill., *Q. robur* L., or *Q. sessiliflora* Salisb. The large areas of shiblyak for the most part occupy ground from which oaks have been cut. The true shiblyak, however, does not consist of forest undergrowth but is an associes of a secondary succession leading again to the climax of oak forest. With the limiting biotic factor of man destroying the trees before they attain their full height, and before a closed forest is formed, the shiblyak remains in the brushwood phase. In addition to consociations determined by a dominant species of oak, *Castanea sativa* Mill. and *Pinus nigra* Arn. form locally pure woods within the climatic zone of the oak woods.

2. *Montane zone.*

Beech association (*Fagus silvatica* L.) is the climax community for the montane zone in the Central European districts of our area and on an average reaches 1,400–1,500 m. altitude. Frequently it forms a relatively pure consociation with only scattered small societies and individuals of other broad-leaved or, especially towards its upper limits, coniferous trees. It is probable that the beech is extending its area at the expense of conifers in many parts of the Balkan Peninsula. This is frequently due to man's destruction of the firs, spruces, and pines which in regenerative power cannot compete with the beech. It is, however, possible that the species *Fagus silvatica* L. as we know it now in the Balkan Peninsula has not yet reached the natural climatic limits of its distribution.

3. *First high mountain zone.*

The conifer communities of the first high mountain zone include the most important climax communities still in a completely primitive condition. They frequently mark the tree limit at an average altitude of 1,700 m. The following subdivisions at least can be recognized, but their relationships are only tentatively suggested:

(1). *Abies alba* Mill.–*Picea abies* Karst. (*P. excelsa* Link) frequently associated as co-dominants but also with one or other in fairly pure consociations. In some areas the line of demarcation between the fir-spruce and the beech associations is not clear.

(2). *Picea omorika* Willk. forms limited communities in western Bosnia and eastern Serbia. Probably they should be regarded as local societies of the *Abies-Picea* association. Phytogeographically they are to be considered as Tertiary relicts.

(3). *Pinus peuce* Griseb. forms limited communities in the central parts of the Balkan Peninsula, and like the last these are probably local societies of the *Abies-Picea* forest.

(4). *Pinus nigra* Arn. occasionally forms societies within the *Abies-Picea* forest.

BRUSHWOOD COMMUNITIES.

It is doubtful if any of the brushwood communities of the Balkan Peninsula are climatic climaxes, excepting in the high mountain zone 5*b*, and, rarely, macchie near the coast. On the other hand it is possible to consider them either as stages in an upward secondary succession, often prevented by the biotic factor of man's activities (including those of flocks and herds) from developing to the forest climax, or as forming a down-grade series, the flora and vegetation becoming gradually impoverished and changed by over-cutting, grazing, burning, &c.

Often the gradual up-grade secondary succession is jerked back, so to speak, but at other times seasonal grazing each year, or practically continuous grazing all the year round, keeps the community relatively stable in what might be regarded as a biotically regulated climax. Examples of the above variations will be given under the headings of the four chief types of 'brushwood' accepted here for the Balkan Peninsula.

Macchie. From the standpoint of their past, present, and potential history four types of macchie may be distinguished as follows: (1) undergrowth to *Pinus halepensis* forest, here forming a layer community; (2) brushwood from which *Pinus halepensis* has been cut out and shows no signs of rejuvenating, the macchie itself tending to degenerate to phrygana or 'rock-heaths'; (3) brushwood becoming more luxuriant and leading to either (1) or (4) as a climax, primary or secondary; and (4) brushwood, without trees, stable and a climatic climax. On the Adriatic and Greek coasts the first and second types are particularly common, while the third and fourth are now, at least, decidedly rarer and, so far as my observations and information go, only occur where protection from flocks and herds and from cutting is enforced. In Dalmatia and southern Hercegovina the second degenerating type is the commonest, and, indeed, it is difficult to draw any line between depauperated macchie and stony or rock 'heaths'. In the central part of the Lapad Peninsula I have seen macchie of the third type exceedingly luxuriant. In western Istria near the northern limit of the macchie I have studied some which probably represent a climax community north of the natural range of *Pinus halepensis*.

Pseudomacchie. These are essentially the hill and montane representatives, especially in the climatically transitional districts, of the Mediterranean macchie. Most often the pseudomacchie are now biologically limited by grazing animals and by cutting, or are degenerating under these biotic influences into phrygana. Nevertheless, they occur under different climatic conditions from the macchie, at least so far as I have studied them, and successionally they would give place to oak and mixed forests if the limiting biotic factors were removed. They may therefore be considered either as regressing under artificial conditions or as progressing naturally to forest according to the local circumstances.

Phrygana. The phrygana communities are always derived from macchie or pseudomacchie as a result of the continued destructive influence of man and his domesticated animals. It is certain that in most phrygana areas a very considerable time would have to elapse before the incoming and establishment of other shrub and tree species would cause an upward succession to high brushwood and forest.

Shiblyak. This easily recognized vegetational type is widespread in the Central European parts of our area. I am not yet prepared to subdivide it into separate associes and consocies, and am not sure how far this may be ultimately possible. The shiblyak (or shiblyaks) represents a stage in the development from deforested ground back to deciduous (oak or mixed) forest. The succession is usually so far advanced that either the forest undergrowth and ground-flora are completely exterminated or have come in a second time, though occasionally it appears that the destruction of forest has never been so complete as to lead to an entirely new secondary succession. The first condition I have seen in various localities in the Nish area and in several parts of Bulgaria, and the last on the hills south of Varna.

High mountain brushwoods. The following communities are recognizable:

1. *Juniperus oxycedrus* L. associated with *Berberis cretica* L., *Daphne oleoides* Schreb., and *Prunus prostrata* Lab. in Crete.

2. *Juniperus communis* L. var. *hemisphaerica* Parl. and *Daphne oleoides* Schreb. associated with *Prunus prostrata* Lab., *Rhamnus prunifolia* S. et S., and species of *Astragalus* in Greece.

3. *Juniperus communis* L. var. *nana* Loud. associated with *Pinus montana* Mill. and sometimes with *Fagus silvatica* L. (as a shrub), throughout the central and western parts of the Balkan Peninsula.

These brushwoods represent the highest and most stable forms of vegetation which develop under the 'subalpine' to 'alpine' climatic conditions in the different parts of our area. The practice of transhumance, with the attendant firing of shrub communities by herdsmen to increase summer pasture, limits their normal spread and even reduces their extent. Often consociations can be recognized within the associations. Thus in the main valley leading to Musalla I have passed through extensive consociations of *Pinus montana* and *Juniperus communis* var. *nana*, each practically pure.

GRASSLANDS.

In the lowlands and hill zone, and even in the montane zone, natural grasslands are of only local occurrence except in the north-east. In the high mountain zone designated 5b they represent a characteristic community probably best regarded as forming associes leading to high mountain brushwoods. The high mountain grasslands are frequently maintained as such and extended by grazing and by the firing of the brushwood. Excessive flooding or a change in the course of a mountain stream may turn them into bog or moor, while avalanches or even exceptional storms may destroy them locally and expose rock or stones.

The steppe vegetation of parts of North Bulgaria and the Dobruja

is doubtfully regarded here as sometimes a climax association. That it is not always so is shown by the occurrences of brushwoods and even forests of varying extent. How far the limitations to development into forest are climatic and how far edaphic and biotic is for our area quite uncertain. Unfortunately I have not yet visited the Dobruja where in the south and centre the steppe vegetation is best developed. The available published data are meagre and inconclusive. Even for the more extensive steppes of South Russia and for the pusztas of Hungary investigators are not in agreement.

The remaining 'grass' communities of the Balkan Peninsula are either artificial or are stages in primary or secondary seres leading ultimately to forest. They are of small extent and of only local importance. The plant communities of stony ground in the lowland and hill zones usually cover surfaces which under an oceanic climate, such as that of the British Isles, would be clothed with closed grassland if subjected to the biotic factor of grazing. They represent the vegetation which has survived the destruction of forests and brushwood and the intermittent assaults of sheep and goats. It is probable that they would form an initial stage in a secondary succession if this was allowed to start, but the earlier phases would in most areas be very slow. Locally in connexion with rivers and streams seres may commence on stony alluvial ground, and secondary seres may follow complete denudation due to the carving away of vegetation and all soil constituents except the stones, as I have observed in South Macedonia.

ROCKY, STONY, AND SANDY GROUND VEGETATION.

In the mountains the ground is usually occupied either by brushwood or by very open herbaceous vegetation, and the habitat varies and fluctuates from rock to bog or stony ground. The climatic climax is coniferous brushwood or forest, except in the highest zone where closed 'grassland' or alpine mats must be a rarely attained climax.

Rocks are exposed over wide areas in the limestone parts of the Mediterranean domain and in most mountainous districts. Often *Pinus halepensis* forest and macchie are growing directly on stony and rocky limestone substratum. Even on the Adriatic karst lands it is surprising how quickly brushwood succeeds open herbaceous vegetation on the much jointed limestone. The stony and rock 'heaths' of Dalmatia have taken the place of macchie or forest destroyed by man. In the higher zones of the mountains the real rock vegetation of cryptogams has not been studied and is, indeed, outside the scope of the present work.

The only area where I have studied extensive successional stages on sand in the Balkan Peninsula, apart from the coast, is to the south of

Varna, where on sandy Tertiary deposits the following sere can be traced:

Seral stages.	*Dominant and characteristic species.*
1. Weed flora of derelict fields:	*Plantago indica* L., *Rumex acetosella* L. var. *multifida* DC., *Agrostemma githago* L., *Filago arvensis* L., *Cynodon dactylon* Pers., *Mentha microphylla* Koch., *Cichorium intybus* L. var. *glabratum* Presl, *Xanthium spinosum* L.
2. Vegetation of a steppe character:	*Lepidotrichum uechtritzianum* Vel., *Xeranthemum annuum* L., *Plantago indica* L., *Artemisia campestris* L. var. *sericea* Koch, *Linaria euxina* Vel., *Teucrium polium* L., *Herniaria glabra* L., *Chondrilla juncea* L., *Eryngium campestre* L., *Scabiosa ucranica* L., *Centaurea sterilis* Steven, *Verbascum glanduliferum* Vel., *Jasione heldreichii* Boiss. et Orph. var. *microcephala* Vel., *Helichrysum arenarium* DC., *Anthemis tinctoria* L., *Achillea compacta* Willd.
3. Shiblyak:	*Paliurus spina-Christi* Mill., *Fraxinus ornus* L., *Crataegus monogyna* Jacq., *Cornus sanguinea* L., *C. mas* L., *Acer campestre* L., *Viburnum lantana* L., *Colutea arborescens* L., *Coronilla emeroides* Boiss., *Corylus avellana* L., and as shrubs or small trees *Quercus cerris* L., *Q. conferta* Kit., *Q. lanuginosa* Thuill., and *Carpinus orientalis* Mill.
4. Oak and mixed deciduous forest:	The above mentioned oaks and the *Carpinus* attain tree size and other species are frequently mixed with them including *Tilia tomentosa* Moench, *T. cordata* Mill., and *Carpinus betulus* L.

SUMMARY.

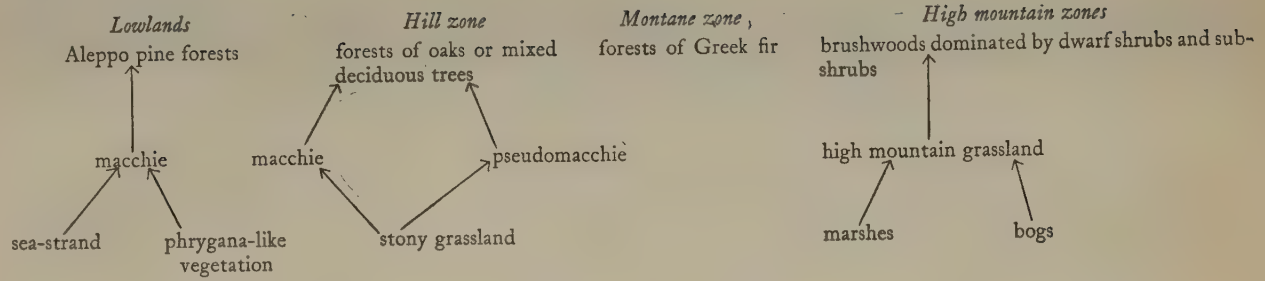
The climax associations differ essentially in the Mediterranean and Central European domains, and so far as can be gleaned by a study of secondary seres the successions terminating in the climaxes are also different, either in all their stages or in the later ones. That intermediate types can be found in the transitional districts does not alter this fundamental fact. The physical factor, or group of factors, which is best used as a basis for the subdivision of the climatic domains is altitude. The high mountain climax communities of the Central European domain extend farther south than those of the lowland and hill zones, this being correlated with the fact that the high mountain climates of south-eastern Europe are more uniform than the lowland and hill climates. Even in Crete and Greece the high mountain

climaxes are not markedly different from those of the central parts of the Balkan Peninsula, and the differences can, in part, be explained by edaphic, geographical, and geological factors.

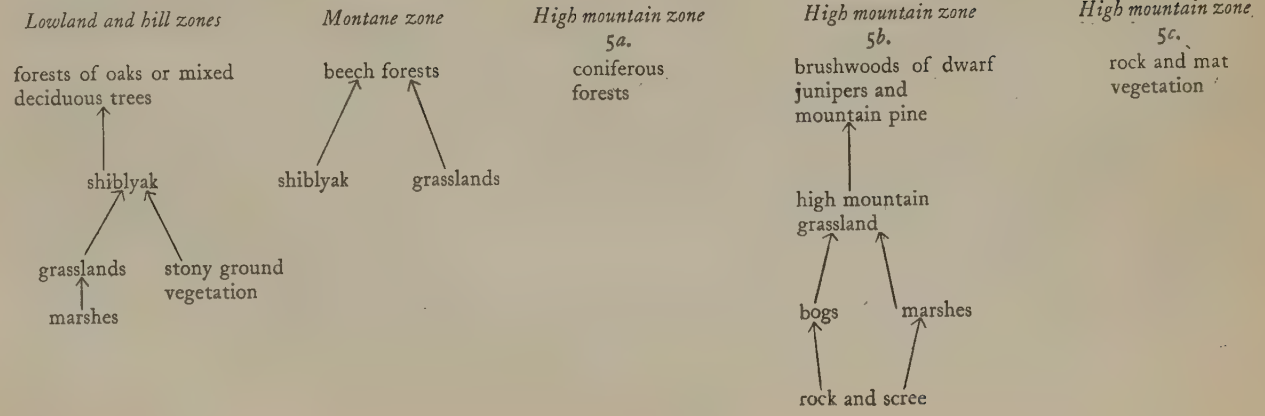
The climax associations in the Mediterranean domain are more open and more xeromorphic than those in the Central European domain. The stages probably take longer to develop, especially the later ones, and rejuvenation after destruction of the climax communities is much more uncertain.

In the broadest outline the climaxes and the most obvious stages of the chief seres, postulating that man's interference is eliminated, can be diagrammatically illustrated as follows:

MEDITERRANEAN DOMAIN.



CENTRAL EUROPEAN DOMAIN.



X

THE INFLUENCE OF MAN ON THE FLORA AND VEGETATION

WEEDS AND RUDERAL PLANTS

General. The Balkan Peninsula includes within its boundaries the homes of very ancient human civilizations. This is especially true of its southern parts—Crete, Greece, and the Aegean isles. Civilized man in organized communities has occupied portions of the Peninsula and surrounding islands for a much longer period of time than he has any other area in Europe. The Balkan Peninsula has also been traversed by numerous lines of human migration from the east and from the north, and has been subjected to many temporary or relatively permanent invasions from the north, south, east, and west. There has thus been both time and opportunity for man to impress changes of considerable magnitude upon the natural vegetation. This he has done, and in any general survey of the flora it is important to remember man's activities and as far as possible to separate his influence from that of 'natural' agencies.

The geographical, geological, climatic, and political conditions of the Balkan Peninsula are, and have been, very different from those of any area in Northern or Central Europe, and both the nature and results of human occupation and activities are different from those in other areas. Naturally the closest comparisons can be made with the other great land-masses which penetrate into the Mediterranean Sea, and especially with Spain and Asia Minor. Italy geographically, geologically, and historically differs considerably.

Man, directly or indirectly, intentionally or unintentionally, alters the flora and vegetation of a country destructively and constructively. It is often impossible to separate destruction from construction; the former precedes or accompanies the latter and the result is a complex combination of loss and gain. Forests are lost and additional pasturage is gained, or brushwood or a nearly bare surface results. Marshes and lakes are drained and arable land increased. Often man's destructive activity leads to natural reconstruction along new lines resulting in a different type of vegetation from that which formerly occupied the area. More often still, in the Balkan Peninsula, the result of man's intermittent interferences is a compromise: for example, some form of shrub-vegetation instead of natural forest on the one hand or artificial pasturage or arable land on the other. Since we are concerned in this chapter with man's influence on the indigenous vegetation and

flora, and not with the crops he cultivates, it is his destructive activities that are mostly emphasized, destructive, that is, of the natural vegetation.

Those parts of the Balkan Peninsula having a Mediterranean type of climate are not always strictly comparable with those which belong climatically to Central Europe. There are, however, such broad intermediate areas and so many with modifying local conditions occasioned by altitude, geographical position, geological structure and history, and physiographical relationship that it is convenient, in this chapter, to consider the facts for the Balkan Peninsula as a whole, specifying districts and localities when necessary.

FOREST DESTRUCTION.

Deforestation has been man's chief crime against nature, and perhaps against himself, in the Balkan Peninsula. Whatever may be true for the parts bordering the Mediterranean there is no doubt that the interior should naturally be covered with forest over most of its area below the altitudinal tree limit.

The relative absence of trees in the lowlands and hill zones caused me on my first visit to the Peninsula (in Greek Macedonia) to compare mentally the physiognomy to that of Iceland where I had previously studied Sub-Arctic vegetation! My first impressions were modified later, but I have personally confirmed in various parts of the Balkan Peninsula the fact that large areas which should naturally be forest-covered are relatively bare. This fact has sometimes been accounted for by climatic changes, local or more general, but most often, I am forced to conclude, it has been the human factor which is responsible.

Prehistoric times. Before dealing with modern conditions we will consider statements relating to ancient times. It is well known that both Palaeolithic and Neolithic remains occur in our region, and the following statement relating to South Macedonia made by Ogilvie (1920) is worth quoting: 'The prehistoric remains of man in the region are nearly all in village sites or tumuli in the clay belt near the sea, from which it has with some reason been assumed that the hills were originally all densely forested. . . .'

Knowledge of the Palaeolithic period in the Balkan Peninsula is very meagre. In Greece no Palaeolithic site has yet been recorded, though animal remains of Diluvial age are known from near Marathon. In Bulgaria at least four Palaeolithic sites are known.

The late Dr. D. G. Hogarth kindly directed my attention to the work of A. J. B. Wace and M. S. Thompson entitled *Prehistoric Thessaly* (Cambridge 1912). In this work very clear evidence is given

that Thessaly was in prehistoric times much more wooded than it is now. Most of the prehistoric sites which occur throughout the area described are in the form of mounds, most of them situated in the plains, but a few are to be found on the foothills. Prehistoric settlements occur everywhere in the plains, except in three small areas in the upper Spercheus valley, in the plain between Phanari and Trikkala, and in the Dotian plain. In the Elassona district (Perrhaebia) prehistoric remains are few. Two small sites alone are known. In the elevated plain to the south of Dhomokos prehistoric remains are also scarce.

The following important quotation is made from pp. 6–7 of the above work:

'In all these places prehistoric sites would naturally be expected and their absence can only be accounted for by the supposition that the country in those districts was for some reason unfavourable for habitation at an early period. It seems likely that the woods of Thessaly which to-day are confined to the eastern slopes of Pelion and Ossa, the north side of Othrys by Ghúra, and the Thessalian slopes of Pindus, formerly extended into the plain and that the forest belt was in certain cases the boundary of the prehistoric inhabitants. Evidence for such forests in the districts where no early remains have been found does exist though it is necessarily slight. In contrast to the bare plain of Larissa, the western extremity of the plain from Phanari to Trikkala and Kalabaka to-day contains some trees. There is no doubt that until recently large woods existed between Trikkala and Phanari. Enquiries made by us in the neighbourhood of the latter town supported this, and Leake (*Northern Greece*, iv. 519) remarks that at Kapá to the west of Phanari he passed through the remains of woods which had not long before been burnt by Veli Pasha, as they were a notorious haunt of robbers. A similar clearing seems to have taken place in the plain of Ayia, where a few trees are still left. Leake says that while travelling from Karalar to Marmariani he lost his way in a wood (*Northern Greece*, iii. 374). Thus in two of the regions where there is a curious absence of prehistoric remains, there is evidence for the existence of woods down to the beginning of the last century. For the other two districts, the plateau of Othrys and Elassona valley, the evidence is not quite so good. In 191 B.C. when M. Acilius (Livy, xxxvi. 14) attacked Thaumaci (Dhomokos) from the north on his way south to the Spercheus, the inhabitants left the town and harassed his army on the march from the woods. How much of this district was wooded is not clear, but in any case this circumstance implies woods by Dhomokos that no longer exist. The district round Elassona is the last region to consider. The obvious road into it from the rest of Thessaly is not by the Meluna pass, which is a mountain ridge made possible for traffic only by an artificial road, but up the Europos valley, which offers an easy route past Dhamasi and Dhomenikos. The fact that there are in this valley several Hellenic sites in contrast to only one on the Meluna route at Karatsholi clearly shows which was more used in classical times. A passage of Anna Comnena (ed. Paris, p. 141; ed. Bonn. i, p. 253) suggests that this valley was wooded. She describes a pass near Larissa, which she calls the palace of Domenikos, where a marshy ravine

enters a wooded plain. This apparently refers to the Europos valley, and if so provides us with a reason why prehistoric remains are rare in this district. Thus in all four districts where prehistoric sites are rare or unknown there is evidence that woods once existed, though it must be admitted that in two cases the evidence is slight.'

Classical times. A careful search through the works of the more likely classical authors has yielded some facts of interest but has, on the whole, been disappointing. Naturally these authors deal chiefly with the southern parts of the Peninsula, Greece, Crete, and the surrounding islands, with some references to Macedonia and Thrace. The general impression obtained from reading the ancient authors is that Greece and the neighbouring countries were then more densely wooded than they are now, but that even before the times of Classical Greece there had been very much destruction of forests. Isolated extracts would scarcely give a fair idea of the evidence available, and it is often difficult to decide their exact value because of poetic licence and credulity in accepting hearsay.

A list of references to statements in classical authors having a bearing on the subject of forest growth and destruction is given at the end of this chapter. Most of them refer to Hellenic lands, for to the Greeks of classical times the interior of the Balkan Peninsula, north of what is now Greek Macedonia, was 'barbarian' country, and being essentially continental there was little intercourse with it till Macedonian and Roman times. Relatively little research work has been done on the undoubtedly rich prehistoric and archaeological remains and deposits of Yugoslavia and Bulgaria which might yield information concerning the vegetation. The evidence for modern times, which is summarized below, and the Central European nature of the climate make it certain that the central and northern areas of the Balkan Peninsula, possibly excluding some of the north-eastern parts and the marshy plains, were originally extensively wooded. Many of the forests must have been denser than the virgin forests ever were in Peninsular Greece and the islands, excepting in the mountain zones.

Within the Mediterranean domain in classical times the various causes of forest destruction, proved below for the modern period, were all active then, as now, but not equally so. Wood was the only fuel, the only ship- and boat-building material, and one of the main house-building materials. The manufacture of lime by the burning of limestone is described by Pliny and by Dioscorides, and the destruction of forests by fire is several times recorded in ancient history. The life of the wooden ships and boats was not long, and their frequent replacement meant the further destruction of available forests. Through Greek, Roman, Byzantine, and Venetian periods of domination this

must have been true, even if less wood has been used for ship-building in the Balkan Peninsula within the last century.

It is important to comment upon the action of sheep and goats in older times. Without doubt this is one of the main causes of the lack of trees in many areas at the present day, but it is doubtful if it was so potent a factor in antiquity as it is now. The domestication of animals had certainly commenced before Minoan times in Crete and both goats and sheep were domesticated in prehistoric times in South-east Europe. The presence of the pig has been demonstrated in the Aegean Archipelago, even as far back as the Neolithic period (see Keller in *Ann. Rep. Smithsonian Inst.* 1912, 483). The cult of the bull was dominant in Minoan Crete. The name tragedy means 'goat-song' and is possibly to be associated with the sacrifice of the goat, the enemy of the vines. It must, however, be realized that in the Balkan Peninsula as a whole, previous to the Slav invasion, the keeping of sheep and goats, which are more inimical to forest rejuvenation than cattle, was secondary to agriculture and olive and vine cultivation. Transhumance was much increased by the Slav invasions of the Balkan Peninsula.

With possible climatic changes before the appearance of man in the Balkan Peninsula we are not here concerned, and the evidence for changes since then is so unsatisfactory and the conclusions drawn by different authorities are so varied, that one can only assume that the general climatic conditions of the Balkan Peninsula were not markedly different in classical times from what they are now. This assumption agrees with the general statement that the southern peninsular and island parts of the Balkan Peninsula, excepting the mountain zones, were formerly more wooded than now, but not densely and continuously so. We know that many lowland areas had much larger swamps and lakes than exist at present. Moreover, with only local exceptions, the Mediterranean lowland climate is not favourable to dense forest growth over large areas.

Middle Ages. We come now to the Middle Ages, where my records are, for the most part, more incomplete and more unsatisfactory than they are for the classical times of antiquity. In spite of much search I have found little which throws light on the use and misuse of vegetation in the Byzantine Empire. Ship-building must have been a continual drain on the forest resources, and the advent of the Slavs led to great increase in the herds of sheep and goats. Much of the timber used at Constantinople, however, seems to have come from the Euxine, Caucasus, and northern Asia Minor (see Gibbon, *Decline and Fall of the Roman Empire*, Ch. xvii, in Methuen's Standard Library Edition, p. 150). The Venetian records naturally concern mainly the western

and southern parts of the Balkan Peninsula. Evidence has been obtained from them that there were in Dalmatia and Croatia especially thick and valuable forests which were exploited by the Venetians and Ragusans. The references to these I have included in the classified list of references given below.

It is necessary to note that during much of the Middle Ages, even after Byzantium had destroyed the Bulgarian Empire, travellers, pilgrims, and historians generally referred to all the territory east of the Morava as Bulgarian, while Anna Comnena, for example, describes the Slavs as Scythians. There are very frequent references to the 'Bulgarian Forest', which at this time was densest between Belgrade and Nish, where now most of the country is relatively open or the slopes are covered with shiblyak (deciduous brushwood). In the First Crusade (1096–7) Walter of Poissy and his host took eight days to penetrate through the 'silvae Bulgarorum' from Belgrade to Nish. Peter of Achery and his army took the same time. Albertus (canonicus Aquensis apud Borgarsium: Gesta Dei per Francos) describes the 'Bulgarian forest' from Belgrade to Nish as 'silvas immensas et inauditas regni Bulgarorum'. The army of Robert of Normandy crossed the Balkan Peninsula from Durazzo by a route parallel with the Via Egnatia into 'Bulgaria', where they had their fill 'of flowing rivers, mountains, and great wastes'. Raimondi de Agiles and his host went down the west of the Balkan Peninsula through Croatia and Dalmatia, from Aquileja, Zengg, and then probably inland—via Žutalokva, Otočac, Lika, Obrovac, Drnis, Muc—and to Salona, Narona, and along the coast to Antivari, Skutari, and Lješ to Durazzo. The wildness of the country in northern Istria, Croatia, and Dalmatia, is emphasized, and thick woods are described as occurring even near many of the 'towns'. It is stated that 'everywhere in Dalmatia are mountains and woods'.

In the Second Crusade (that of Conrad, 1147) the Bulgarian wood is again mentioned (e.g. by Arnold). A town Ravenella (Ravno) lay in the middle of a wood and its inhabitants are referred to as 'Serbs', this being the first time Serbs are mentioned for the district of the Morava. In the Emperor Barbarossa's Crusade the 'silva Bulgariae' between Belgrade and Nish was again traversed. In 1922 and again in 1926 I made careful observations along this route. There are practically no traces left of the 'silvae Bulgarorum'. In addition to the cultivated areas, there is much shiblyak, shiblyak in process of being succeeded by secondary forest, and obviously secondary and much exploited woods.

Recent times. We have now to consider how trees and forests have been destroyed from the Middle Ages to the present, and are still

being destroyed. For convenience of reference I have classified the various data collected under subject headings, and the arrangement under each of these is, with few exceptions, chronological. Only selected examples and citations are given here. References to publications, under the names of authors, will be found in the literature quoted at the end of the chapter.

Cutting for timber.

Wood-cutters on the Athos Peninsula are mentioned by Leake (iii, p. 126), who says that the monasteries levy a small contribution upon them. Pančić remarks on the wholesale destruction of woods on the serpentine mountain line, from Kopaonik to the Belgrade plateau, by wood-cutters. *Fagus silvatica* and species of *Quercus* had especially suffered. Tozer (ii, p. 4, 1869) noticed at the landing place near Katrin, at the foot of the Thessalian Mt. Olympus, piles of sawn timber ready for exportation. Jackson (p. 293) states that in A.D. 1292 in Ragusa the only buildings of stone were the churches and the castle, all the rest being of wood hewn on what are now the barren slopes of Mt. Sergio. A fire, which broke out on August 16, 1292, burned to the ground the greater part of the city. Jireček says that timber for houses and ships is provided by the whole of the Balkan chain, the Rila, Strandja, and the Deli Orman. From the Balkans, via Kotel, the timber goes to Varna and Adrianople. The great wood export from the Rila and Rodope is to Sofia, Philippopel, Constantinople, and even, via Dede-Agač, to Smyrna. Philippson in his work on Thessaly and Epirus has many references to timber cutting. The pass of Purnaraki was formerly clothed with oak woods, but these were destroyed to supply the needs of the railway (p. 25). The water parting between the rivers Spercheios and Aspros, at 1,330 m., shows evidences of forest destruction (p. 103). On Mt. Ithamos, the wood of oaks and firs was being cut in many places by Slav lumbermen (p. 108). In the region of the upper Aspros there has been great forest destruction, especially of firs, since the region became Greek. The Aspros contains much water, and the trunks are floated to the Gulf of Patras from the heart of Pindus. The Aspros is the only Greek river so used. The lumbering is done by Bulgarian lumbermen, and the timber is bought by speculators from Trikkala or Patras. In a few years there will be no more firs in this area (pp. 288–9). Trees were being cut in the valley of Smigos (p. 299) and in the valley at the western foot of Koziakas (p. 310). High-stemmed trees have long since disappeared from the Arta basin (p. 388). Tozer (p. 279, 1890) records a small vessel lying off Pallene (the westernmost peninsula of Khalkidikē) in readiness to carry timber to Salonika. Ginzberger and Maly, referring to the

Almost deforested slopes in the south central Rodopes, near Buju, at 1,200 m. Scattered and low beech trees (*Fagus silvatica*) occupy the ground from which the humus has been almost entirely washed away.

The western Rodope massif in the conifer zone, with the summit Elni Vrh or Malevica in the background, reaching to 2,731 m. (Photo communicated by N. Stoyanoff.)

Illyrian lands, state that some places, as Delminium (Županjac) and Metulum (Munjava), were mostly built of wood, which was felled in the neighbourhood. A favourite way of felling a tree in various parts of the Balkan Peninsula is to light a fire near the base and to burn through the lower part of the trunk. The blackened stumps alone remain to witness the destruction. Thus, Baumgartner describing the island of Meleda says that gaps with burnt stumps occurred in the wood of *Pinus halepensis* near Blata. On the Suva Planina and on the Vitoša I have noticed that the conifers are usually the first trees to be cut for timber. They are often unable to re-establish themselves in competition with the beech and its dense shade. Košanin says that in the Shar Planina region stumps of conifers can often be seen in what are now beech forests. Tozer (ii, p. 122, 1869), too, notes the absence of conifers on Pelion: though they were present in antiquity they are now largely replaced by oaks and beech. Historical details of the cutting of timber in Hercegovina, and its export via the Narenta river, are given by Patsch (pp. 38 seq.). Zon and Sparhawk (pp. 236 seq.) state that for Yugoslavia the annual wood growth is estimated at 690,000,000 cubic feet and the annual cutting at 783,660,000 cubic feet, so that the forests are being considerably over-cut. Bosnia annually exports 211,800,000 cubic feet of timber, one-third of which goes to Italy. There are many saw-mills using steam- and water-power. Austria carefully exploited the forests, but even before the war there was over-cutting in some areas. In August 1925 I examined stumps of *Pinus halepensis* in the Lapad Peninsula near Gruž (Gravosa). The trees had been clumsily cut down by axes to within two or three feet of the ground. The macchia left in the place of the forest was of the same floristic constitution as that forming the undergrowth in the untouched parts.

Between Bačkova and the old Turko-Bulgarian frontier, and some kilometres beyond this, much timber was being cut in the summer of 1926. I saw about a dozen large saw-mills using water-power from the streams. The usual simple mechanism is to take off water into wooden trough canals from one to several kilometres above the mill, and, keeping the canal with a more gentle gradient than the stream, to allow the water to emerge at the lower level with a rushing fall so as to turn a wooden wheel. The trees are usually cut into rough timber planks at these mills and the large heavy planks are taken to the South Bulgarian plain in clumsy wooden wagons, drawn by horses, mules, or oxen, or big roughly-squared trunks are dragged along in pairs crosswise on the backs of mules and donkeys. Smaller tree-trunks, branches, pollarded trees, and saplings, are carried on the backs of donkeys and hinnies. In the Ilyina valley (the second valley from the

Rila monastery) I examined a great dam of timber, quite deserted in 1926, and below it an intermittent series of smaller dams and long wooden canal troughs continued nearly to the junction with the Rilski river. Many tons of slightly trimmed timber were rotting away. A concession had been granted to exploit the forests of the upper part of the valley, work had commenced but for some reason had completely ceased with enormous financial loss, and much damage to the forest had resulted in little of economic value. On the limestone mountain above Bačkova the beech wood had been destroyed during the two years previous to my visit in 1926. Great piles of cut timber were awaiting transport, and it was evident that the conifer forest above was being prepared for the usual destructive exploitation. Stumps and poor brushwood occupied the former beech zone but much black humus was still present in a fair depth of soil. In this respect the area formed a very interesting contrast with the many long deforested areas I have examined whence all humus and nearly all soil had disappeared. The primitive untouched oak and beech forests on the northern side of the Karlik Dagh in the southern Rodopes and the primitive beech and conifer forests of the Rila district showed even more marked contrasts with long denuded areas. Beyond Dolni Pasarel to Samokov isolated trees and forest patches indicate that not long ago this area was forest covered. Exploitation for timber is still proceeding in many parts. Thus in *The Near East* for September 23, 1926, p. 345, it was stated that an Austro-German group had been granted a concession to exploit the forest land in the region of Kritchim-Dovlen, situated in the Rodopes to the south of Philippopolis. A similar concession was also to be granted for the forests of Malko-Tirnovo and Vassiliko in the eastern Rodopes. These forests are in relatively inaccessible places and for this reason had been hitherto saved from destruction.

Timber for ship-building.

In the Middle Ages Venice, Genoa, and Byzantium, and later the Ottoman Empire, were great maritime and naval powers. The massive construction of that period employed relatively large timbers, as is well shown in the Civic Museum at Venice, but apparently without a proportional increase of strength. The numbers of vessels built and the losses in war and by storm, as given by the older historians, indicate how great a drain on the forests were the navies and mercantile marines. The old modes of ship-building have been partly handed down to the present day in the Mediterranean region, and there one often sees even very small vessels in whose construction huge beams and thick planks have been employed.

The following extract from the papers of Dr. Hunt (see Walpole, pp. 228–9) is worth quoting:

'We left Misvoro (in Khalkidikē) early in the morning . . . at 6h. 40′ we reached a most beautiful plain. . . . The oaks here are so well adapted for naval purposes that they have been ordered to be sent to the dockyard at Constantinople. Some have been felled, but as it will cost fifty piastres to bring each of them to the shore, a bribe will probably be given to the government inspector for reporting them unfit for ship building, and thus the people of the neighbourhood will escape this addition to their heavy imposts.'

Holland (p. 329) says: 'The timber of Salonika is chiefly obtained from the shores of the gulph, particularly in the vicinity of Katrina, and is well adapted to the purposes of ship-building, for which it is conveyed to Malta, and other parts of the Mediterranean.' Leake (i, p. 181), referring to the district of Préoyza, near the Gulf of Arta, in Epirus, says Lasalle here built vessels on his own account and also had a contract to deliver at the arsenal of Toulon, for five francs the cubic foot, oak timber, to be marked in the woods by persons appointed by the French Government. He bargained with the Greeks or Albanians to bring the trees down to the waterside. Lord Broughton, who travelled with Byron, also says 'the woods of Albania, before the French revolution, furnished Toulon with timber for ship-building'. Hassert states that the French authorities in Napoleon's time cut off the tops of trees in an oak-wood near Trieste in order to obtain straight growing trunks. The trees all died as a consequence! Forest destruction around the Adriatic is often stated to have begun with the Venetians, whose devastation seems to have been more thorough than that of the Ragusans. Hassert says that the old records of Adelsberg (Postumia) and Wippach indicate that by 1620 there was no wood fit for shipbuilding from the coast to beyond Adelsberg and that the destruction had been going on for 300 years. Shipbuilding from the earliest days of the Republic of Ragusa formed an important industry. The timber was obtained from the forests of Mt. Sergio, Lagosta, and Meleda, as well as from Bosnia. Mt. Sergio is now bare of trees, except for cultivated olives on the lower slopes, a few scattered pines, and a patch near the top. Traces of forests still remain on Lagosta and Meleda. Ragusa had her last dispute with Venice in 1754 when she complained to the Porte that the Venetians had illegally cut down forests in Ragusan territory, and levied exorbitant tolls on Ragusan vessels. Villari (1904) makes many references to the large numbers of Ragusan merchant and war ships. Ginzberger and Maly insist on the Venetian destruction of forests. On the lower course of the Narenta shipbuilding wood was felled and exported. In Brštanik near Bočitelj at the end of the fourteenth century there was a dockyard.

Cutting for fuel for domestic use and for bakeries.

The scarcity of fuel is characteristic of many parts of the Balkan Peninsula. Coal is rare or entirely absent, and even what is mined is of relatively poor quality. The same is true of peat, which I have never seen used or dug in the Balkan Peninsula. In Macedonia I have seen dung mixed with small quantities of earth and thrown on to a wall to dry in the sun to form small 'brickets' for use as fuel. It is true that fires for warmth are not needed so much in the Mediterranean parts, where wood is on the whole most scarce, as in northern Europe. Yet for private cooking, and for the public bakeries of the larger cities, considerable quantities of wood or charcoal are consumed. In 1917 I saw daily for some weeks when camped a few miles outside Salonika, donkey loads of brushwood being taken into the city for sale and for use in the communal bakeries. The commonest plant thus used was *Quercus coccifera* L., which was often rooted up entire. Sibthorp (see Walpole) records that wood of *Pistacia lentiscus* L. was much esteemed for fuel and also for making the lye for the manufacture of soap. Leake (i, p. 164), referring to the Bay of Lutráki in Acarnania, says 'the beach is covered with firewood, piled in stacks for embarkation'. Of Mt. Mitzikéli near Yannina (iv, p. 164) he says it is stated to have been formerly wooded on the side facing the city, as it is on the eastern side. The court (of Ali Pasha of Tepelen) still used much wood, 'and one of the severest oppressions to which the villages in the district are subject is their obligation to deliver it in the city at their own expense. Every village in its turn, whether in the vicinity of a forest or not, is liable to this imposition.' An interesting account of the importation of firewood into Zara is given by Alschinger. The following plants yield the main supply, in order of importance: *Pistacia lentiscus* L., *Arbutus unedo* L., *Juniperus oxycedrus* L., *J. phoenicea* L., *Quercus ilex* L., *Phillyrea media* L., *Erica arborea* L., *Viburnum tinus* L., *Cistus* spp., and *Myrtus communis* L. These are especially brought in by ships from the coasts and islands. *Pinus halepensis* Mill. is only brought in from Curzola (Corcyra nigra). The following species are exceptionally brought in by sea: *Amygdalus communis* L., *Olea europaea* L., *Prunus cerasus* L., *Morus alba* L., *Prunus spinosa* L., *Ficus carica* L., *Ceratonia siliqua* L., and *Paliurus spina-Christi* Mill. From inland there are brought in on the backs of horses and asses and in carts: *Quercus lanuginosa* Thuill., *Q. robur* L., *Q. cerris* L., *Carpinus orientalis* Mill., *Acer campestre* L., *A. monspessulanum* L., *Fraxinus ornus* L., *Ulmus campestris* L., *Prunus mahaleb* L., and *Viburnum lantana* L. Two other plants often used as fuel are *Euphorbia spinosa* L. and *Helichrysum italicum* Guss. The poverty of parts of Bulgaria in

fuel is emphasized by the fact that in some of the Danube areas (e.g. near Vidin), and also near Slivnica, bricks are burnt on straw fires (Jireček). Near Bačkova in the Rodopes, and between here and Ustovo (Čatak), and also near Samokov, I have seen great quantities of logs cut for firewood, piled up in stacks, being floated down the river, or being transported on donkeys driven by boys. At Varna, near the railway station, logs were piled up in August like coal stacks at an English station. Loads of firewood on ponies were coming into Philippopolis in July. Along the valley ending at Stanimaka the logs are floated down the river. Men with long poles guide them in places, and I also saw a stake catch-trap and one mill with a side-stream so arranged as to float the logs into the mill. Mahaffy, in the district near Nauplia, saw 'the natives dig up the roots (of shrubs) for fuel, and we met dozens of donkeys on the way bringing loads of such roots home for burning'. In August 1925 in Ragusa harbour, and later in the Canale di Calamotta, I saw many boats the size of large barges filled with firewood brought from the coast and islands. Most of the pieces of wood were about as thick as a man's wrist or leg. Similar boats were also filled with charcoal, many of the pieces being of smaller diameter, about that of an ordinary walking-stick. The firewood and charcoal represented the destruction of numerous small trees and shrubs. On the Lapad Peninsula I saw the destruction of macchia for firewood. The shrubs were roughly hacked down and allowed to dry before being carted away. On Mt. Sergio (Sergi) the very depauperated macchia was also being cut for firewood and even the roots were being got out for the same purpose. Later in the month I saw small trees and shrubs of *Fagus silvatica* L. being cut down on Mt. Lovčen, and peasants carting the wood and carrying bundles of it on ponies or on their own backs into Cettinje and Cattaro.

Charcoal making.

I saw considerable quantities used by the British forces in Macedonia in 1917, and since then I have noted its general use in many parts of the Peninsula. *Quercus coccifera* is much used in Attica, as in Macedonia, and is mentioned in this connexion by Aristophanes. In ancient times Mt. Parnes furnished the wood which caused the neighbouring deme of Acharnae to be famous for its charcoal—the *ἄνθρακες Παρνήσιοι* of the Acharnians of Aristophanes. Leake (ii, 420) records that Parnes still supplied the charcoal for Athens, but that the demand was not so great as to cause any great consumption of wood in the manufacture of it, and that the people of Menídhi and Khassiá, who had succeeded the *ἀνθρακεῖς* of Acharnae in its manufacture, had not to ascend very high in the mountain for their material. Pritzel noted

that the large *Quercus conferta* forest of Kapellis in Elis was being exposed to unsparing destruction by the charcoal-burners, and what woods were left were diminishing and being replaced by macchie and other communities. Krebs (p. 145) notes that the pine woods near Ušce below 600 m. are being denuded by charcoal-burners and pitch-makers. Patsch (p. 28) gives striking historical data for the destruction of woods by charcoal-burners in Hercegovina. In July 1926 I saw charcoal-making in progress near Buju in the south-central Rodopes.

Smelting.

In antiquity and in the Middle Ages the Balkan Peninsula was famous for its metalliferous ores. These were mined in considerable quantities, those yielding the precious metals of gold and silver being especially prospected. An interesting account of the silver mines of Laurion in the Attic peninsula is given in Baedeker's *Greece* (ed. 4, Leipzig, 1909, p. 123). The Archaean and igneous central core of the Balkan Peninsula has many areas containing heavy metal ores. The working of these in antiquity is frequently referred to by Casson (see especially pp. 57–79). In July 1926 I explored some old Roman mines in the central part of the southern Rodopes in an almost inaccessible place near Buju. The principal ores were galena with some silver and a little gold, zinc blende, tin blende, and copper pyrites. How the produce from the mining was taken to the plains can scarcely be guessed. Mining operations had just recommenced under a Bulgarian engineer but transport problems had still to be solved. It must be remembered that the only fuel available for smelting in olden times was wood or wood-charcoal and the aggregate destruction of forest for this purpose must have been very great.

The Turkish traveller and geographer, Hadschi Chalfa (the name is transliterated in various ways), mentions the old ironworks near Vlasina. The last remains of the industry did not disappear till 1878 when the area was joined to Serbia. The only fuel was wood, and the industry lasted for centuries. Hadschi Chalfa also refers to the silver and copper mines around Kratovo (Karatova), saying that in the neighbourhood the mountains are denuded of forest and bush and yield only pasture for flocks. The gold, silver, lead, and iron produced by the Bosnian and Serbian mines were largely smelted by wood fuel at Ragusa. The modern mining developments tend to use coal and water-power, or by better means of transport to export the unsmelted ore. A full account for Yugoslavia is given by Wray. In August 1926 I saw a large brick and tile works near Eski Dschumaja at which much timber was being used as fuel.

Lime-burning.

The production of lime by the burning of limestone is a very ancient process referred to by classical authors, though it must be noted that lime-mortar was not used in ancient times to the extent it is now. It is still responsible for a certain amount of wood destruction in the Balkan Peninsula. Thus in August 1922 I saw lime-kilns being illegally stoked with beech brushwood on the limestone Suva Planina at about 1,200 m. altitude. The high beech forest had been largely destroyed previously, and the after-growth and young saplings were now being sacrificed for lime-making, though the men in charge had no official permit for wood-cutting. Patsch (p. 29) reproduces a photograph of a lime-kiln in the Bregava Valley above Stolac, Hercegovina. The inhabitants of the village of Kastanítsa, on the slopes of Mt. Malevo, in Laconia, specialize in lime-kilns. They travel widely in the Peloponnese, often earning a respectable fortune at their work.

In addition to yielding timber and fuel, forests and trees in the Balkan Peninsula are exploited in other ways. It is necessary here to emphasize that this exploitation is carried on in a rough empirical manner, with little or no thought for the future. The permanent damage is thus often out of proportion to the temporary income, and, though some kinds of exploitation are less objectionable on this score than others, the sum-total of destruction is by no means negligible.

Tapping and cutting for resin, turpentine, and 'pitch'.

Speaking of Scio (Chios) Tournefort (p. 286) describes the making of incisions in mastick trees (*Pistacia terebinthus* L.) in early August, and the collection of the 'grains' or 'tears'. He also (p. 287) refers to the cross-cutting of the trunks of the biggest turpentine trees from the end of July to October; the turpentine runs down on flat stones placed under the trees. Sibthorp (see Walpole) records *Pinus halepensis* Mill. (*P. maritima* Lamb.) as furnishing a resin, tar, and pitch. The resinous parts of the wood are also cut into small pieces and serve for candles. A quotation from Leake (ii, p. 380) is worth giving here:

> 'The road now leads along the side of the Sarandáforo, through a forest which seems as if it would not long exist, as the greater part of the trees are in a process of destruction for the purpose of collecting their resin to make pitch. All the bark having been stripped off towards the foot of the tree, and a part of the wood cut away, a hollow is made in the ground into which the turpentine flows: the trees which lean a little are preferred, the reservoir and incision being made on the upper side. The process may be repeated for several years before it kills the trees.'

The use of resin in wine is an ancient custom in Greece.[1] Mahaffy

[1] See Plutarch, *Sympos. Quest.* 3 and 4, p. 528, ed. Wytten.

(p. 162) notes in the rising country near Pentelicon 'old fir-trees, all hacked and wounded for the sake of their resin, which is so painfully obtrusive in Greek wine'. Maunsell notes for the Rodope that resin, or 'katran', is boiled out from the pine wood in large pans, where it is burnt with charcoal, the resin running out of a hole at the bottom.

The production of resin from *Pinus halepensis* is the subject of an interesting memoir by A. Oekonomopulos. The annual production in Greece is estimated at 8,000 tons, of which 5,000 are used in chemical industries and 3,000 in adding to wine. Upon standing 30–36 hours after it comes from the tree, the resin contains crystals of pinic and oleic acids; the ethereal oil is practically pure dextrorotatory pinene. The four methods of chipping that are commonly used (Helis, Sophiko, Kundura, Angistri) differ somewhat in the form and size of the faces and the methods of catching the resin. Experiments are described in which the streak method, and various modifications of it, were compared with the Kundura and other chipping methods. The flow of resin lasted 53 to 296 hours, and the volume of resin flowing in an hour per unit length of streak varied directly with the average temperature for the period. There was a daily fluctuation in the rate of flow, with maxima at night and minima during the day. The best yields were obtained from shallow streaks, 2 to 4 cm. deep, repeating each streak once after the first flow ceased. Resin obtained by the streak method contained 27 per cent. turpentine, compared with 17 per cent. for the chipping methods. The streak method causes less injury than chipping and boxing, which may result in the death of the tree.

Collection of tanning materials.

Tournefort (p. 18) says the inhabitants of the island of Zia in the year 1700 gathered above '5000 Hundred Weight' of Velani (fruits of *Quercus aegilops* L.). The young fruits gathered off the tree were considered more valuable than the fallen ripe ones. Clarke (pp. 436–7) also remarks that the great article of export from Zia (Keos or Kea) consists of the acorns of *Quercus aegilops*. In Greece the gathering of acorns and acorn-cups of this oak is legitimate and free after August 10 in nearly all state forests (Zon and Sparhawk).

The collection of sumach, *Cotinus coggygria* Scop. (*Rhus cotinus* L.) is an important minor industry. The wood is crushed and employed in tanning in Bosnia and Hercegovina.[1] The bark and twigs are collected in Bulgaria, especially in the hill lands of the Danube (Jireček).

[1] See *Gard. Chron.* December 18, 1880, p. 791.

Holbach (p. 144) refers to numbers of children being employed to collect the leaves of sumach near Jelec in Bosnia. A modern tannery and leather factory had been erected by the Austrian Government and the leaves were used in tanning skins to a fine colour.

Miscellaneous exploitation.

According to Hawkins (quoted in Walpole) the seeds of *Pinus pinea* L. are collected with great industry in Elis, and are exported to Zante, Cephalonia, and other places. The wood of *Arbutus unedo* L. is used by turners, and flutes made of it are used by Greek shepherds. In Zante a spirit is drawn from it and a vinegar of a bright gold colour (Walpole). *Cotinus coggygria* Scop. yields a beautiful orange-yellow dye for yarn, and is used by Greeks and Albanians, and sold to dyers in Athens (Walpole).

Destruction by fire, more or less wantonly or by neglect.

Leake (p. 420) records an accidental fire which destroyed much forest on Mt. Parnes, and also mentions (p. 159) an accidental fire which destroyed a great part of the woods of fir from which Mt. Elato in Cephalonia derives its modern name. 'The bare stems are now', he says, 'conspicuous monuments of the misfortune.' Boué (p. 12) speaks of the destruction of forests by fire as seen in 1837 in Bosnia between Mokro and Novakasaba, and again (l.c., p. 13) he deplores the lack of forest control in Serbia, and says that near Stoudenitza they saw a whole wood of pines burnt solely to obtain an extract of tar. Velenovský (Suppl., p. 331) mentions seeing considerable areas of burnt-down woods in the Balkan chain and on the Vitoša. A forest conflagration on one of the hills in northern Euboea is described by Miller (pp. 230–4), and in Baedeker's *Greece* (ed. 4, Leipzig, 1909, p. 114) it is stated that the woods of Pentelicon, especially those on the south slope, 'have recently suffered greatly from fire'. Trevor-Battye (p. 165) travelling through the Psykro glen, about eight miles from the southern end of the Gulf of Mirabella in eastern Crete, noted the destruction, largely by fire, of extensive areas of pine forests. Blackened stumps witnessed the careless and wasteful work. He speaks several times of the practice of burning through the butts of trees as the cause of forest fires. To the south of Ragusa I saw an area of badly burnt-out macchia in August 1925. The burning of woods and brushwood for purposes of extending pastures is dealt with below. Bourchier (see Grogan, p. 240) mentions 'a vast conflagration' raging in the forest of Belova about thirty miles from the Rila Monastery. In 1925 a large fire destroyed much forest on the slopes and hill-tops on the north-east side of the Rila valley above the monastery. When I visited this area in the summer of 1926 the bare and partly blackened

trunks were being cut and taken away by the narrow gauge railway which now runs to the middle Struma valley. The forests in this valley are protected from ordinary exploitation.

Destruction in war and against brigands.

Peter Mundy (p. 84) so long ago as 1620 noted destruction of forests near Borovaglava, a plateau of the Prologh mountains in Bosnia, near the Dalmatian boundary. He says: 'Wee came to a plaine called Borvagaglava, where wee dyned. Before wee came to this plaine, wee ascended another high mountain. . . . On either side were other Hills whose topps were covered with Snowe, with Forrests of Pine trees and a little farther were whole woods of them cutt downe to the ground. To prevent Theeves that usually lurked amonge them.' Noel Buxton (see Maunsell) has remarked that in 1904 much forest had been destroyed on the Government (Turkish) initiative on the south side of the Rodopes to make it impossible for refugees to hide on the mountainside. Radovanovitch (see Stead, ch. xvi) has recorded that in the wars with Turkey in 1876 to 1878, and in the war with Bulgaria in 1885, great stretches of forest were felled along the Serbian frontiers, near Turkey, Bosnia, and Bulgaria, either for strategic reasons or for the needs of the army. In the recent war I did not see any conspicuous damage to woods or trees committed by British troops, but Doflein (pp. 39, 79, 183, 433, 501) refers very definitely to the destruction of woody vegetation by German and Bulgarian troops in 1917–18. The destruction of an old wood of *Juniperus excelsa* near Lake Doiran in 1916 by Bulgarian soldiers is recorded by Stoyanoff (p. 48), who counted up to 172 rings in some of the trunks, and, since the insides were hollow, he estimated their age as at least 200 years. Villari (p. 102) states that the forest of Kindrovo, not far from Vodena, was assigned to the Italian Army (in Macedonia), 'and it was there that timber was cut for trench and barbed wire supports, and firewood for the bakeries and heating. There was plenty of raw material, but every now and then a breakdown occurred on the railway and for a time no more wood could be transported; and then every expedient had to be resorted to to procure the necessary fuel'.

Damage to woody vegetation by grazing animals and prevention of rejuvenation.

The destruction of woods and the prevention by grazing animals of their immediate rejuvenation has disastrous consequences in many parts of the Balkan Peninsula, not merely different in scale but in quality from anything seen under the oceanic climate of the British Isles. In the Mediterranean districts of the Balkan Peninsula the processes of soil formation by both mechanical and chemical weathering

are much slower than in more northern climates. The soil, especially on slopes, is shallower and the solid rocks are more easily exposed. Moreover the strong winds, such as the bora and the Vardar winds, help to remove exposed soil, and the humus of woods is quickly dispersed when the trees are destroyed. I have observed also that in coastal macchie, in pseudomacchie, and in shiblyak the humus covering is very or relatively scanty. Humus does not form to the same extent in brushwoods, whether evergreen or deciduous, or mixed, as in high woods. Hence the natural tendency is for stony and rocky ground to appear in the former, rather than for rejuvenation of forest to occur, and this apart from the action of grazing animals. An excellent instance is afforded by the Sorigna woods in Arbe where forest destruction is still proceeding (Morton). The tall trees are cut or burned down, sometimes even their roots grubbed up, while the smaller ones are much eaten. There is no care for the aftergrowth or seedlings. Bare rock is appearing, and invaders such as *Paliurus spina-Christi* Mill., *Helichrysum italicum* Guss., and *Scolymus hispanicus* L., have entered from communities outside the woodland. A very considerable difference was visible even after a five years' interval. In the Karst areas of the north-west Balkan Peninsula the limestone is of a high degree of purity, i.e. its ultimate breaking down leaves little solid residue, and deforestation has certainly had the result that this residue and the humus are quickly carried to the sea by the drainage of water, for the annual rainfall is not light. The bora and the scirocco also play a part in dispersing the results of disintegration.

Conclusive evidence has already been given that forest destruction has been widespread in the Balkan Peninsula from very ancient times down to our own epoch and is still proceeding. It is however, necessary to emphasize here that it is not the mere destruction of the trees which causes the permanent deforestation of large areas, but the prevention of young growth and natural reforestation. It is certain that the feeding of flocks of sheep and goats is the chief cause of this, and that if their indiscriminate wanderings and the practice of transhumance were prevented much land would naturally revert to forest. On the northern slopes of the Krusa Balkan to the north-east of Turica in 1917 I saw a good example of this actually occurring. During the Great War the villages of the Struma Plain and the northern slopes of the Krusa Balkan were evacuated by the inhabitants. Some of the villages had also been destroyed in the Balkan Wars of 1912–13. Moreover, the wandering Kutzo-Vlachs with their flocks were not permitted in this area. Although this reservation had only lasted for a short time, partially for about 4 years, intensively for 1–2 years, the brushwood (partly shiblyak, partly pseudomacchie) showed all the signs of vigorous

and luxuriant growth and over-topping trees were appearing. This was in marked contrast to very similar areas farther from the fighting line, where transhumance was continued, even if somewhat modified by war conditions. Again in the districts of settled agriculture, where the antagonism of the farming population sufficed to keep out the nomad or semi-nomad shepherds, local tree-growth was a conspicuous feature. Thus around the Turkish village of Jeni mah, east of Karamudli, and in a rich sheltered valley on the south of the Krusa Balkan, well-developed trees abounded between the cultivated fields, on the sides of ravines, and as patches of forest.

Goats were domesticated animals in the time of the Prehistoric Swiss Lake-dwellers and indeed, in Switzerland, during the Neolithic period, the domestic goat was commoner than the sheep; and this very ancient race of goats differed in no respect from that now common in Switzerland (Darwin, ch. iii, p. 124). Several breeds were kept by the ancient Egyptians. The wild goat (*Capra hircus aegagrus*) is even now found in Crete (also in Asia Minor, Persia, &c.) and formerly inhabited many of the Aegean Islands. The ancient Greeks and Romans paid great attention to the rearing of goats and they are frequently mentioned in their literature, especially in the Greek pastoral poems, from Homeric times onwards. Wild browsing animals rarely affect natural tree vegetation to any considerable extent. Their numbers in forest areas are not great, they usually only resort to this source of fodder when other kinds are lacking, and this lack is not in the season when new growth is made by the trees and shrubs. The domesticated goat, on the other hand, will often feed upon woody branches in preference to low herbage, and this especially when young shoots are in the season of most active growth. The goat has a markedly hard palate and tongue and strong teeth which enable it to break or tear off and masticate even tough and thorny branches. There is probably no other domesticated animal, except perhaps the pig, which will eat so great a variety of food as the goat. Experiments have been made which show conclusively that the goat will eat a far higher percentage of plant species than cattle, sheep, or horses (see Pegler). Both sheep and goats in the Balkan Peninsula appear to be much more omnivorous than they are in the British Isles. To the north of Salonika on February 24, 1917, I saw sheep and goats eating a dead sheep, and in Sofia on August 20, 1926, I saw a goat pulling down and eating paper advertisements. Dr. Nisbet, in *The Forester*, 1905, says 'Goats, however, poison the shoot with their bite'. This seems to me extremely unlikely and, in spite of wide inquiries, I have been unable to obtain any positive evidence for it.

It is important to remember that the breeding and care of domesti-

cated animals and the attention given to pasturage is much more primitive in the Balkan Peninsula than in the Alps, Carpathians, or Western Europe. The stall-feeding of farm animals, artificial pasturage, and the cultivation of forage plants is almost unknown. The obtaining of winter fodder is often an acute problem. I have made an attempt to introduce root crops into Bulgaria, but it is doubtful how far climatic conditions would justify growing them on a large scale. A certain amount of hay is made, and I saw a good crop being carried on the Liulin Planina, in Bulgaria, in August 1922, but for sheep and goats the winter fodder is the twigs and leaves of trees, especially of oaks and beech (see Hassert, Košanin, Degen, Jireček). These are sometimes collected in large quantities (Bulgarian, *listnica*), and Patsch (p. 25) says, of the Sandschak Plevlje in 1907, that for one winter's fodder for one goat valued at four crowns, 'prudent' peasants destroy forest material of 200 crowns value! In the southern part of the Rodopes between Daridere and the Graeco-Bulgarian frontier, in July 1926, I saw numbers of Pomak women laden with great bundles of beech branches collected for fodder. At Buju, on July 21, 1926, I saw horses and mules fed on freshly-cut green beech branches which they seemed heartily to enjoy. Throughout the central and eastern Rodopes and in many other parts of the Balkan Peninsula the columnar or cone shape of most of the trees, especially of *Fagus silvatica* L., is a striking feature in all the easily accessible and unprotected parts. It is due to the use of the lateral branches as green fodder for domesticated animals. I have also seen trees peculiarly pollarded for use as storage places for hay. A platform is made by leaving the lower branches on which the hay is piled around the trunk. Either the whole of the top of the tree is then cut away or above the hay pile the branches are allowed to remain as a sort of roof taking the place of thatch.

In order to enable the reader properly to appreciate the influence of sheep and goats on the vegetation some figures may be given. Seidensticker quotes Arrian vii. 9 to the effect that only small mountain herds of sheep were met with on the ranges of Macedonia. It is certain that the coming of the Slavs very largely increased the keeping of large flocks, and it must be remembered that their influence penetrated deeply even into peninsular Greece. However it may have been in ancient times, the Balkan Peninsula is now overrun with small and large flocks of sheep and goats. Sibthorp (see Walpole) computed Attica to have 100,000 goats and 60,000 sheep. Holland (p. 43) states that it was estimated that in the year 1811 there were, in the small island of Cerigo, 16,000 sheep and goats, about 1,300 horses, and 2,500 oxen. In 1887 Jireček calculated for the whole of the (then) principality of Bulgaria 6,871,949 sheep, 1,203,985 goats, and 394,843 swine.

Miller (pp. 230–4) says that in proportion to its population Greece had more goats than any other country, and that there were 119 goats to every 100 Greeks, which (at that time) brought up their number to 2½ millions, and in the country they were ubiquitous. According to Haračić, the communes of Ossero, Lussinpicolo, and Lussingrande in Lussin, with an area of 4,816 ettari, of which 2,468 were classified as 'pasture', had 19 horses, 101 mules, 133 donkeys, 199 cattle, 184 goats, 9,181 sheep, and 666 pigs (an ettaro = 2·47 acres). Patsch (p. 27) gives the number of goats in Hercegovina in 1910 as 619,448, that is, 120·44 per square kilometer. According to *The Near East and India* for September 3, 1925, Macedonia and Thrace produced approximately 500,000 lambskins, 300,000 sheepskins, and 180,000 kidskins during 1924.

In Bulgaria the census of live animals taken in 1900, 1910, and 1920 gave the following results:

	1900	1910	1920
Sheep	7,015,385	8,669,260	8,922,604
Cattle	1,596,267	1,606,363	1,877,108
Goats	1,405,190	1,464,719	1,331,853
Horses	494,557	487,222	398,240
Buffaloes	431,487	412,978	418,209
Pigs	367,501	527,311	1,089,699
Donkeys	108,098	118,488	155,581
Mules	8,887	12,238	25,714
Poultry	4,751,751	8,688,853	7,293,958

The figures for 1900 and 1910 are for Bulgaria as constituted before the first Balkan War, those for 1920 are for the country with the boundaries laid down in the Treaty of Neuilly (1919).

For Greece the Ministry of National Economy in 1912 published the following figures:

	Horses, mules & donkeys	*Cattle*	*Sheep*	*Goats*	*Pigs*	*Fowls*
Continental Greece	91,432	77,200	969,997	901,455	70,215	554,247
Euboea & N. Sporades	15,993	14,899	146,993	157,563	7,128	98,854
Thessaly . .	72,939	86,245	815,626	354,430	29,517	403,985
Arta . . .	2,789	6,873	50,549	61,349	1,096	31,869
Ionian Is. . .	22,696	8,913	109,169	84,040	8,598	206,234
Cyclades Is. . .	12,990	13,655	63,118	62,093	9,093	57,257
Peloponnese . .	142,498	96,429	1,389,990	1,017,113	101,529	1,176,874
Totals	361,337	304,214	3,545,442	2,638,043	227,176	2,529,320

In August 1925 I had many opportunities of seeing the damage being done in macchie, phrygana, and even olive woods, by sheep and

goats in southern Dalmatia and Hercegovina. Here the flocks are mostly small, averaging about a dozen animals, but they are very numerous and very little escapes their attention. Between Bačkova and Čepelare in the central Rodopes, in July 1926, I observed numerous large and small herds of goats feeding on the hills. Again at Ustovo (Čatak) there is a large area of deforested ground on which goats are pastured, effectively preventing rejuvenation of woody communities.

Indirect evidence is obtained of the influence of flocks on the tree vegetation by a comparison of the Aegean islands one with another. Thus the Cyclades are bare of natural tree vegetation, with very few exceptions. On the contrary, Skyros and, especially, the Magnesian islands (northern Sporades) have forests, which only within recent years have begun to disappear before the attacks of the axe, fire, and the ravages of sheep and goats. The sea-faring folk of the Magnesian islands, and somewhat less of Skyros, have needed relatively less pasture land than has been claimed at the expense of woodland in the Cyclades (see Philippson).

Transhumance

This is, and has been for centuries, widespread in the Balkan Peninsula. It is described for northern Greece by Leake (i, pp. 351, 353), and Dedijer, Jireček and Cvijić also deal with its problems. An interesting account is given by Holland (pp. 91 seq.) in 1815 for Epirus. He describes a cavalcade of migrating shepherds and their flocks nearly two miles in length, with few interruptions. In Albanian and western Macedonia it is the Klementi, the Vlachs of the Pindus and Grammos, and the Macedonians of the neighbourhood of Okhrida, who bring the herds from the mountains to the coastal plains in winter. In the Aegean area the plains from Thessaly to Gallipoli are favourite winter resorts, and I have seen large flocks on the plains to the west of Salonika in winter. The itinerary of the Roumanian 'Mokkanes' between the mountains of Transylvania and the lowlands of Roumania and the Dobruja is well known. They tend to move down to the Danube each year on the fall of the flood waters to feed on the lush meadow vegetation. Thus Antipa estimated that the Balta of Braila alone, in one year, contained 100,000 cattle, sheep, pigs, and horses. In Bulgaria transhumance is especially carried out by the cattle herdsmen of the central Sredna Gora, by the shepherds of the Kotel Balkan, by the Vlachs, and by the Turkish Yourouks. The Bulgarian herdsmen are not so nomadic as the Vlachs and the Turkish Yourouks, but in the Kotel Balkan the nomadic tradition is well remembered. The 'Srednogorci' winter in the lower Maritza basin or near Burgas, and the shepherds of Kotel in the Pontic lowlands of the Dobruja and Thrace,

especially near Karnobad, as they have done for years. The number of animals in the mountains in summer is given by Jireček as 525,000 sheep and goats in the Sliven district, and 560,000 in the Sofia district. Košanin, dealing with the Shar area, says the herds there in summer number up to 6,000 sheep and goats and that they winter in the Campania and Thessaly, returning to the mountains with the first appearance of vegetation. At the end of May 1910 Cvijić met 15 to 20 flocks totalling 50,000 to 60,000 sheep going to the mountains along the route between Vodena and Pazar (Janica). The name 'katuni' is given in Serbian to the alpine or subalpine localities to which flocks go in the summer. Thus Baldacci mentions the Katuni of Dolovi. In the central parts of the Balkan Peninsula it is especially the Vlachs ('Aromounes' of some writers, also Vlasi, Valaques, Kutze-Vlachs), a race of disputed origin, but whose language is akin to Roumanian, who are the wandering shepherds. Pastoral migrations of the Vlachs of Thrace are mentioned as early as 1285, and those of the Vlachs of Thessaly in the fourteenth century. In Serbia proper and in Bulgaria, and, indeed, in the Balkan Peninsula generally, transhumance is on the decline. In Serbia the pasturing in the lowlands is not now through the whole winter but is divided into two grazing seasons, spring and autumn, and the former wide wanderings of the shepherds have ceased. The old herd migrations from Rascia to the Danube and Morava have stopped, and there is an increase in arable cultivation and cattle-raising, which, as in Central Europe, tend to go hand in hand.

Burning to increase pasturage.

In order to increase and improve available pasturage shepherds frequently fire brushwoods and young forests. While some of the conflagrations attributed to shepherds are no doubt accidentally caused by fires lit for warmth, cooking, or to keep off wolves, there is no doubt that many have been started deliberately. Košanin (pp. 208 seq.) records seeing large areas burnt by shepherds on the Jakupica and Shar Planina. Patsch (pp. 23–6) records the destruction of forests and brushwood by herdsmen to form new pasturage in Hercegovina. He also quotes authorities for similar destruction in Bosnia, southern Dalmatia, Albania, Serbia, Thrace, and Macedonia. In 1917 I saw extensive fires started in South Macedonia, south of Lake Doiran, for the purpose of improving pasturage amongst open hill brushwood.

Dropping of dung.

It is known that in Central Europe the congregation of animals, especially in night resting-places, modifies the flora by the accumulation of their excreta. Pax refers to it in the Dobruja, but the only

instances I have noticed personally were in the Rila mountains where around certain cattle pens formed of sloping planks there were giant specimens of species of *Artemisia*, *Chenopodium*, and *Urtica*.

Destruction of woods to obtain arable land.

This has no doubt been done more extensively in the past than it is now. I have seen it done on the lower slopes of the Suva Planina in eastern Serbia. On sunny and not too steep slopes the destruction of woods gives valuable soil for cereals because of the high humus content.

Place-names.

Information derived from a study of place-names has to be used with great care. It is often probable that names derived from words meaning forests, or woody vegetation, or some species of tree, indicate the past or present existence of these in the neighbourhood, but one cannot always be sure. Tozer (1869, ii, pp. 107 seq., and 1873, pp. 58, 153 seq., 340, 341 seq., 362) gives many Greek examples. It may be noted that the special name for a wooded mountain, Ida, does not occur on the continent of Greece. Of Slav names Bukova, Bukovina, and Butkovica mean 'the beeches'; Arachova, 'the nuts'; Navarino, 'the maples'; and Vervena, 'the willows'. Hassert referring to a district in Montenegro mentions that Butkovica means beech associations, and Han Gvozd indicates 'primitive forest' which has there disappeared save for a hedge of old beech trees. Dubrovnik, the resuscitated name for Ragusa, means 'the woody', though now scarcely applicable with the bare limestone slopes of Mt. Sergio behind it. Jireček gives some Bulgarian examples as: Brezje (Okolya Iskrec), Brezov Dol (near Ogoja), the Bryazova Reka, Brezovica, Breznik, Brezovo (near Elena), from breza, the birch. Ginzberger and Maly say that the names of many places in the Karst are derived from trees which do not now occur, or occur sparsely, in the neighbourhood. Many names signify a richly wooden district, e.g. Drievo (= wood), the old name of Gabela. The highest point of the island of Leucas is called 'Elati' from the fir-woods which once covered it, though no traces of them are now left. The island Corcyra nigra (Curzola, Korčula) received the designation from the dark colour of its dense pine woods, of which now (1925) there are only patches.

Miscellaneous evidence.

A certain number of data are not classifiable under the above heads, but some of them are of considerable importance. These will be given here in approximately chronological order.

Tozer (1869, i, p. 50, 1873, pp. 44–5, 1890, p. 284) contrasts the extensive tracts of forest in Samothrace and Thasos with the treeless landscape of Lemnos. Archilochus's description of Thasos as 'an ass's backbone covered with wild wood', is as true now as when he wrote, the gaunt but picturesque line of its dorsal ridge standing prominently out from its wooded heights. Schaffer has published a paper on forest destruction in the Ergene basin, Thrace, but I am sceptical of the figures by which he attempted to show that 2,000 square kilometers of forest had disappeared in that region in the twenty-five years after 1878. Baldacci (1904) makes general references to forest destruction in the western parts of the Balkan Peninsula. Albania and Montenegro, however, contain richer forest lands than probably any other districts of the Peninsula at present except parts of the Rodope massif. It is stated that the forests around the river Arzen and those between Kruja and Alessio were being worked for the production of charcoal, firewood, and timber, while those between the Drin and Boyana are largely exhausted. Ginzberger and Maly mention that in Illyrian lands Roman remains have been uncovered in districts which are now stony wastes, yet cisterns or buildings for water-storage have not been found. Moreover, the contents of graves, in which roe and stag antlers and bones, and teeth of the wild boar, are found in large numbers, show that there must have been formerly a well-wooded district with natural springs.

Maunsell gives a few details regarding the destruction of forests in parts of the Rodopes. Thus the Chadir Kaya plateau was formerly well-wooded, but now has only patches of wood and scattered pines, stunted and gnarled by being lopped for firewood. Sprenger (1912–13) gives some evidence that Corfu was formerly covered by forests. Protected and planted trees flourish in the Park of Achilleion. Monks have protected the woodland on Hagia Maria, and in this forest humus is well developed and typical woodland plants (as *Ruscus aculeatus* L.) occur. *Ruscus* is also found on Mt. Pantokrator, but the woods have quite disappeared here. The island of Paxos, which has edaphic and climatic conditions very similar to those of Corfu, has large woods of *Pinus halepensis* Mill., which stretch from the hills to the sea-coast. An account of the probable relationship between deforestation and the increase of malaria is given by Regnault. Rikli speaks very strongly for the former great extension of cypress woods in Crete, both on the mountains and down nearly to the sea-coast. The Cretan wild cypress is all of the horizontal variety. According to Theophrastus cypress woods occurred on Mt. Ida but there are none there now. A detailed account of the conifers of Mt. Vitoša, in Bulgaria, is given by Petkoff, and evidence is stated for the former wider

distribution of some of them (pp. 64–5). Much forest has certainly been destroyed on this mountain and the destruction is being continued. Krebs (p. 56) quotes Boué (1854) as indicating forest between Koračica and Belosavci, where it has now (1922) been much reduced in area. Patsch (p. 23) makes a comparison between the present condition of Mt. Lovćen in Montenegro and its condition as described for the year 1614 by Mariano Bolizza, a patrician of Cattaro (Kotor), who says the mountain was then well supplied with fresh water, and that all day there was shade given by numerous and very agreeable beeches, ash-trees, and pines. Stebbing (31, footnote) mentions that whilst at the Serbian front in Macedonia in 1916 he was informed that the treeless state of the country was supposed to be due to an old Turkish law which assessed the amount of taxes to be paid by landowners according to the number of trees they had growing on their land. To diminish the amount of taxes to be paid the landlord cleared off all his trees and thus brought the hill-sides to their present bare state. I have not succeeded in confirming this.

The general impression I gained from a careful study in 1925 in Dalmatia and southern Hercegovina was that wood destruction is there going on more quickly under Yugoslav rule than it did under the Austrians, that tree-planting has practically ceased, and that restrictions on cutting, &c., are even more 'only on paper'. That much of the central and southern Adriatic sea-board could, and should have, forests of *Pinus halepensis* and of high macchie becomes evident after field study. Thus the south-west of the island of Lesina is now very largely bare of forest. The greater part is either bare rock or is covered with depauperated forms of macchie so that even a decent sized shrub stands out conspicuously. That trees can grow here to a good size is shown by the few patches of forest left here and there, not only on the lower slopes but even up to the central ridge, as near Mt. S. Nicolo. It is unlikely that the steepest ridges were naturally forest-clad, but apart from these I could see no reason why a belt of *Pinus halepensis* and macchie forest should not extend over the whole island but for man's interference. The same remarks are true for the western parts of the peninsula of Sabbioncello, whose south-eastern parts are, on the contrary, fairly well wooded. Curzola, especially at its western end, is still much more wooded than is Lesina. It is also much less steep.

Bourchier (see Grogan, p. 253) mentions the destruction of forests on the northern slopes of the Rodopes during the construction of the main railway through Bulgaria.

One effect of deforestation which has impressed me considerably, is the carving of steep ravines (or nullahs) in soft strata by heavy rainfall where the surface is unprotected by forest or brushwood. In several

parts of South Macedonia and in the sandy Tertiary deposits near Varna overlooking the Black Sea this is very obvious in just those places where forest and brushwoods have been destroyed. Near Čakal and Dolni Pasarel in the Rodopes I have seen the same phenomenon on steep denuded hill-sides.

FOREST CONTROL.

Aristotle in his *Politics*, vii (vi) 8, 6, mentions *ὑλωροί* or commissioners of woods and forests, who were appointed to see to the proper administration of the woodlands. All of the present states of the Balkan Peninsula have legislation for the protection of forests and regulations for their exploitation. Many of the laws are admirable, and the only fault is with their administration and especially the laxity of it. As a Bulgarian friend said to me when discussing this question 'in orders we are very rich'. Forest administration and the granting of concessions for exploitation is frequently connected with politics, and there is much bribery with many threats used in gaining 'forest rights'. Obviously this corruption increases the destruction. The rotation and replanting of forests, except in those parts of the Balkan Peninsula formerly administered by Austria, has only been carried out on a small scale. Few or no attempts to control tree diseases and forest pests have been made. Thus Trevor-Battye (p. 203) describes a forest of *Quercus ilex* L., north of Sphakia, in the Krápi district, Crete, which seemed doomed from the ravages of the gipsy-moth (*Ocneria dispar*). In Bulgaria and Serbia I have seen areas of badly diseased fir, spruce, and oaks, though only locally. Amusing accounts have been given of attempted reforestation in Greece. Thus Miller (pp. 187–8, 230–4) says that Lycabettus has been partly reforested, but the trees have to be fenced for protection. In December 1903 the dasarch (or forest official) of Elis decided to replant that part of Olympia which lies between the excavations and the hill village of Drouva. The peasants at once protested that they had enjoyed the right of pasture there for many years, and threatened resistance. It is said that when a Greek sees a tree his first thought is concerned with how to cut it down. In a local train from Sofia to Philippopolis on July 14, 1926, I saw a printed notice urging people to take care of the forests. Between Samokov and Čamkorija, in the Rodopes, is the best evidence of forestry I have seen in the Balkan Peninsula. Near here there was in July 1926 clear evidence of properly controlled felling, replanting, and protection for natural rejuvenation. The trees at Vranja Royal Park, in the King Boris Gardens, and near the Theological College, Sofia, indicate that dense forest could again clothe even the Sofia plain.

The fact that reforestation has succeeded in places, as I have seen

Limestone pavement in the karst-lands, north of Trieste, between Briščiki and Sessana. Karst brushwood in the background.

Limestone district on the western slopes of Mt. Maggiore, Istria, in the montane zone. The beech forest has been partially destroyed and practically no humus occurs on the ground. A rich, but open, vegetation of herbs and suffruticose plants, however, occurs.

in various localities north of Trieste, in the Istrian Peninsula, in Dalmatia, and in Hercegovina, shows that the climatic and edaphic conditions are often not in themselves inimical to tree growth. The early seedling and sapling stages, however, need much careful attention and protection. According to *The Times* of January 7, 1927, the Italian Government has decided to put a tax on goats. It will be interesting to see if this has any effect on the ravages of these animals in those north-western parts of the Balkan Peninsula now included in Italy.

Effect of afforestation on the Karst vegetation. The Austrians established numerous plantations of pines (especially of *Pinus halepensis*, its variety *brutia*, and *P. nigra*) on the Karst in many places. These are spreading naturally at a very slow rate, and I could find very few seedlings establishing themselves. On the other hand the Italians seem to be leaving the plantations and brushwood untouched, that is, they are not yet 'exploiting 'them, and at my second visit, after three years' interval from the first, I noticed a decided increase in the woody vegetation for the Karst north of Trieste. A study of the flora of several of the pine plantations, estimated at 25 to 30 years of age, showed some of the influences of tree growth on the ground surface and vegetation. Relative to the unforested Karst outside the plantations the surface was well covered with groundflora, especially with grasses, *Dactylis glomerata* L., *Brachypodium pinnatum* Pa.. de Beauv., *Sesleria autumnalis* F. Schultz, and *Melica ciliata* L. being predominant and often forming an almost closed turf. The pine needles had formed a humus 1 to 3 inches in depth and little bare rock or stone was visible. The undergrowth (of karst shrubs), except in the more open parts, was meagre, but shade-loving species of herbaceous plants were found, such as *Thalictrum minus* L. var., *Helleborine latifolia* Druce, *Betonica officinalis* L., *Inula conyza* DC., *I. squarrosa* L., and *Polygonatum* sp. According to Cieslar (1922) the yield of plantations of *Pinus nigra* Arn. (*P. laricio* Poir.) established in 1859 on typical limestone karst near Basovizza was, in 1914, two to four times that of natural and planted stands of the same age in other parts of (at that time) Austrian territory.

Trees or forests regarded as sacred or saved by superstitions. The extent to which woods or individual trees have been protected by religious or superstitious associations is a debatable subject. Seidensticker gives very complete lists of groves and trees sacred in Greek and Roman times to some god or goddess, or reverenced because of a supposed connexion with some semi-divine hero. However, one so often reads in the ancient authors of the burning or felling of sacred groves by an enemy, that it would appear that their renown often led

to their destruction rather than to their preservation. An anonymous writer, in *Wiener Allg. Forst- u. Jagd-Zeitg.* xxxviii. 310, 317, 319 (1920), has suggested that the devastation of Greece began when a fanatical Christianity destroyed first the sacred groves and later extended its work to the mountain forests, which were regarded as the haunts of pagan gods. I have no confirmation of this. On the contrary, there is evidence that destruction was well advanced in Greece before the Christian epoch, and that more secular causes fully account for it.

Jackson (1887, p. 164) quotes Fortis as mentioning a wood near Poglizza (Mt. Mossor), which the inhabitants still name after a heathen Slav deity Virun. Petrovitch (p. 19) has the following interesting paragraph

'. . . every forest, lake and mountain has each its syen, which is called by a Turkish word *djin*. So, for example, the djin of the mountain Riyetchki Kom, near the northern side of the lake of Scutari, does not allow passers-by to touch a branch or a leaf in the perpetually green woods on the mountain side, and if any traveller should gather as much as a flower or a leaf he is instantly pursued by a dense fog and perceives miraculous and terrifying visions in the air. The Albanians dread similar spirits of the woods in the region round Lurya, where they do not dare touch even the dry branches of fallen firs and larches.'

The reference to 'larches' here is wrong, since no species of *Larix* is known to occur in the Balkan Peninsula in the wild state. An interesting paragraph occurred in *The Observer* newspaper for November 16, 1924. It is there stated that near Ochrida Christians and Mohammedans jointly 'rose' to preserve a holy tree from desecration and destruction by employees of the Yugoslav Posts and Telegraphs Ministry. There are traditions of the worship of this tree in the Middle Ages during the reign of the Serbian Nemanja dynasty.

CEPHALONIA, ITHACA, AND ZANTE.

In concluding this subject of the modifying influence of man on the woody vegetation it will be interesting to consider the history of a single district. I have chosen Cephalonia, Ithaca, and Zante, three of the Ionian islands, because many data are available (see especially Partsch). The climate here is very suitable to forest growth, and there is no doubt that naturally the islands should be almost entirely clothed with dense forests. Even now the peak of the chief mountain massif of Cephalonia, from its southern end up to the pass of Agrapidiaes, is clothed with extensive high-stemmed woods of *Abies cephalonica*. The forest reaches nearly to the highest point of Aenos (1,600 m.) and extends down to 1,000 m., and even lower in the south and on the north-eastern slopes. The forest of Mt. Rudi, and the greater woodstretch, the Melanitsa, along the axis of Aenos are to be included.

The forest practically encloses Aenos, so that this mountain is given the name Elatovrini or Monte Nero, and all Cephalonia is designated Melaena.

The fir forest of Cephalonia was well known in ancient times, but much of it must have been destroyed before the Venetian conquest. An additional motive for the conquest of the island was provided by the Spanish fleet making a stay here and landing men in order to obtain wood (Marino Sanuto, *Diarii* iii. 1104, 1140). At this time transport to the sea was already difficult, the wood having to be dragged from the forests in the dry season. The Venetians domiciled in Homala a colony of some 200 wood-cutters and carpenters to work wood for their fleet and fortresses. The exact date of the establishment of this colony of 'marangoni' is not quite certain, but probably it was in the early years of Venetian dominance, for a big emigration took place in 1501.[1] The colony is referred to by Ang. Basadonna (1590) and by Ambr. Corner (1597). In 1517 much wood was cut down for fortress building in Zante.[2] In 1574 Vic. da Molin mentions the sending of much wood to Zante for the rebuilding of the fortress. In 1655 Dom. Michiel delivered '15 migliara de palli' for the fortresses. The impression given by the laws formulated by the Provveditori (purveyors) is that the woods of Cephalonia were being quickly destroyed over much of the island. There is the record of a very extensive fire at the end of the sixteenth century. Andrea Corner in 1677 established a fire-fighting statute. In the seventeenth and eighteenth centuries the wood must still have had a considerable extension on the eastern side of Aenos, towards Pyrgi, though this area is now very largely waste ground. Fires are recorded again in 1730 and 1760 (near Pigi), and in 1797 a very devastating one destroyed more than half of the then remaining forest. Laws for forest protection had little permanent effect, though plenty were made against both wood-cutting and animal grazing up to and during the English occupation of the Ionian islands. A Captain Walker lost his life in 1849 as a forest-preserver. The forest is still being reduced.

Most of the other mountains of the Cephalonian group of islands have been deforested. In the sixteenth century remains of oak-woods in Ithaka were still so considerable that, before the extension of vine and olive cultivation, acorns and cups formed the most important product of the island. Thus Vic. da Molin (1574) writes: 'Theachi non fa oglio, ne vini, se non poca quantità, ma fa delle valonie.' In 1590 the inhabitants defended their forest remnants, still valuable as hiding-places when enemy landings occurred, against a Cephalonian invasion (Ang. Basadonna 1590). Now Mt. Neriton is bare and only

[1] M. Sanuto, *Diarii*, iv. 74. [2] Ibid. xxiii. 559.

on the east slope of Merovigli above Perachoris is there a light wood of deciduous trees.

DRAINAGE OF LAKES AND MARSHES.

Of man's destructive influences on the vegetation of the Balkan Peninsula the most pronounced has been that which affected the woody plants, especially the high forest. Of secondary, and much less, importance has been the draining of marshes and lakes. This has been mainly intentional, and, from the human standpoint, constructive, but the marsh flora has been reduced in extent, and species which, in all probability, were at one time much more widespread are now extremely local, or even exterminated in some of the districts. It must be remembered that there has been a natural drying up and draining of large lake areas in the Balkan Peninsula since Sarmatian and Pontic times, and it may be that this is scarcely yet completed. Thus in the Dragoman and Sofia basins the process of natural shrinkage of marsh and lake has gone hand-in-hand with artificial drainage schemes for the purpose of obtaining agricultural land. This was certainly the impression I gained by a study of the Dragoman marsh in 1922. It is of interest to note that some well-known species of marsh plants are extremely rare in Bulgaria and very probably are relicts of a former wider extension. As examples the following may be mentioned: *Hottonia palustris* L. (Kazičenskoto blato, in the Sofia basin), *Caldesia parnassifolia* Parl. (Dragoman marsh), *Elisma natans* Buchen. (Sezlinescko), *Sparganium simplex* Huds. (in a few scattered marshes), and *Trapa natans* L. The last named plant occurs in a few widely separated localities in Bulgaria, and it was surely at one time much more widely distributed, for Pliny and Dioscorides record that the inhabitants of ancient Thrace (i.e. in part the South Bulgaria of to-day) made bread from the fruits. Theophrastus (*Enquiry into Plants*, IV. ix) apparently indicates that *Trapa* grew in the Strymon (Struma), but I have no modern record of it in this river.

The best-known drainage scheme of the Balkan Peninsula is that concerned with Lake Copais (Orchomenos) in Boeotia. This lake is about 100 m. above sea level and is surrounded on all sides except the south-east by mountains 600 to 1,000 m. in altitude. These mountains are formed of Cretaceous limestones above with sandstones and shales below. The rainfall of the district is about 900 mm. per year (compared with about 500 mm. at Thebes) and is markedly seasonal. Naturally the lake drained by subterranean courses (*katavothra*) to the sea. Large areas of the Boeotian plain were turned into marsh when the *katavothra* became blocked. There are traces of old drainage canals in the basin. The lake originally covered an area of 58,080

acres. Theophrastus (*Enquiry into Plants*, IV. x–xi) has an interesting account of the vegetation of this lake, and this needs comparison with the modern conditions. An account of the earlier modern work and schemes is given in *Petermanns Mitteilungen*, xxxv. 71 (1889). In 1890 the drainage-works were taken over by an English company, now known as the Lake Copais Company, Ltd. The following details are taken from the speech of the chairman made at the ordinary general meeting on July 16, 1925[1]: The area of land cultivated during the year 1924 was 31,107 acres, an increase of 4,424 acres. Crops were harvested from 29,690 acres, a larger area than has been harvested in any year since 1918. An additional 2,321 acres of low-lying land, which had gone out of cultivation, were brought under the plough, and that season some 4,375 acres of tough, couch-infested land had been broken up and sown with oats, and it was expected that it would be possible to deal with a further similar area during the next season. Cotton had become the most remunerative crop on the Copais. In 1925 a contract was signed by an American company for the drainage of parts of the Lower Vardar basin, and operations were to start in the next spring in the district of Lakes Amatovo and Ardzan.[2] A full account of the proposed reclamation is given in the *Commerce Bulletin*, No. 50, December 1925 of the United States Department of Commerce. The 'Vardar concession' involves the drainage and irrigation of the Salonika Plain, approximately 800 square miles in extent, lying west of the city of Salonika and largely formed by the alluvial deposits brought down by the rivers Galikos, Vardar (Axios), Loudias, and Vestritza (Aliakmon), which now traverse it from the mountains to the bay. These rivers frequently flood, and in addition approximately 300 square miles consist entirely of swamps and great shallow lakes. Of these, Lakes Amatovo and Ardzan are first to be drained. The Vardar is then to be regulated and controlled and its lower course is to be altered back to the old channel it occupied fifteen years ago. The great Yenitze swamp, between the Vardar and the Loudias, is to be drained. The entire project is estimated to occupy 5½ years before completion. Casson (p. 4) has suggested that the Romans probably drained the Philippi plain, north-west of the present town of Kavala.

Davidoff (1906) gives an interesting account of the changes in the flora in the neighbourhood of Varna within recent years. The spreading of the vineyards on the hill-slopes to the north of the town led to the destruction of much natural and semi-natural shrubby and herbaceous vegetation. The town 'sea-garden' has been much extended and the nature of its soil changed with consequent changes in the

[1] See *The Near East and India*, xxviii. 120 (1925). [2] Ibid. 551 (1925).

flora. The extension of buildings also destroyed much of the vegetation. Ruderal plants were introduced and sand-dunes were stabilized, changing their maritime flora to an inland one. The destruction of woody vegetation on the hill-slopes increased the erosion of these and caused the bringing down of large quantities of sand, which covered a considerable area and completely changed the vegetation. Till 1902, there was marshy ground between the old and new stations of Varna with a characteristic freshwater marsh vegetation. At the end of that year a new channel was cut and the marshes drained, so that the level of lake Djevna (Gebedže) fell 55 cm. The whole locality became drier, and in place of marsh vegetable gardens and maize fields were established in which a xerophilous weed flora appeared. Lake Djevna is now (1926) connected by a channel with the sea and its waters are becoming saline. At the eastern end I noted the invasion of salt-marsh plants, and the crayfish, which were formerly abundant throughout the lake, are now restricted to its western parts.

MISCELLANEOUS INFLUENCES OF MAN ON THE FLORA AND VEGETATION.

Astragalus physocalyx Fisch. has only been collected near Philippopolis. It is said to be extinct there now, owing, at least partly, to the activities of two plant collectors. The only living plants known in 1926 were three in cultivation at Sofia and Vranja. *Dianthus multinervius* Vis., a species only known from the small island of Pomo, is apparently now extinct [see Hirc in *Rad. Jugosl. Acad.* cxc. 184 (823) (1912)].

The collection and use, and even sale, of wild plants for medicinal purposes is general in the Balkan Peninsula. Although this involves some destruction, it is doubtful if it is ever more than a very minor factor in modifying the flora and vegetation. The gipsies of Varna sell wild herbs and bunches of wild flowers in the streets of the town, but this is little more than a pretence for begging. It is especially in the spring that flowers are hawked by these people. *Galanthus nivalis* L., *Scilla bifolia* L., *S. bithynica* Boiss., *Leucojum aestivum* L., and *Primula vulgaris* Huds. var. *rosea* (Boiss.) being gathered for the purpose in quantity. In August 1922 I visited a herbalist's room in the small monastery on the Liulin Planina. Large bunches of plants were drying and these included *Gentiana cruciata* L., *Achillea* spp., and various *Labiatae*. Dalmatian insect powder is made from the heads of *Chrysanthemum cinerariaefolium* Vis., often cultivated but sometimes collected from wild plants. *Rosmarinus officinalis* L. is used on Lesina and Lissa for making rosemary oil. *Teucrium chamaedrys* L. is known throughout Bulgaria as a medicine for malaria. A Pomak at Boju, in the south-central Rodope, told me it is drunk as 'tea', four

or five small twigs being boiled for fifteen minutes in about a teacup of water. Street sellers of *salep* are to be seen in all the larger towns of the Balkan Peninsula. The powder from which the drink is made is obtained from the tuberous roots of various species of *Orchis*. The name *salep* is of Arabian origin (tha'leb) and probably came into the Slav languages from Turkish. In Macedonia *Sideritis scardica* Griseb. and, probably, other species of the genus also, are used for making 'tea'. In Bulgaria I have seen considerable quantities of inflorescences of *Tilia tomentosa* Moench collected and dried for 'tea' making. The leaves of *Inula helenium* L. are sometimes added to cigarette tobacco in Bulgaria. In Dalmatia young shoots of *Ruscus aculeatus* L., *Asparagus acutifolius* L., and *Smilax aspera* L. are used as vegetables. Fishermen on the islands use the leaves and shoots of halophytes, and the flower-buds of *Capparis* are also employed. Both Serbs and Bulgars are very fond of flowers and many of the beautiful wild species are used for house and personal adornment. At holiday times and festivals the peasant women deck their hair and dresses very tastefully and vases of flowers are frequently to be seen in dwelling rooms. In 1926 the unusually wet summer season caused the Vitoša meadows to be extremely floriferous and we saw many Bulgar 'tourists' returning with armfuls of beautiful flowers, amongst which *Trollius europaeus* L. was usually conspicuous. The proximity of the Vitoša to Sofia is undoubtedly causing a deterioration in its flora.

THE WEED AND WASTE GROUND FLORA OF THE BALKAN PENINSULA.

Agricultural methods. Before dealing with this subject it is necessary to consider briefly some facts relative to the methods of living and of agriculture pursued in the Balkan Peninsula. The division of the land into fields separated by hedges and walls is not nearly so frequently seen in the Balkan Peninsula as it is in England, and one can scarcely give a separate enumeration of 'hedgerow' plants. On the other hand, there is usually much more waste ground in and around villages and towns than there is in England, and the paths in and between villages afford main routes of migration for ruderals. Excepting a few main roads and those constructed for military purposes, the connexion between village and village is by more or less worn paths, whose surface has only been modified by the wheels and feet of traffic. Again, it must be noted that 'seed' crops are rarely kept as clean as they are on the average in Western Europe. Only the simplest agricultural implements are used on arable land, ploughing is usually very shallow, and the fairly frequent practice of leaving land to lie fallow always means that there is a big stock of buried weed seeds. Moreover, the climate is favourable to annual weeds.

Vine and olive cultivation is of peculiar importance in many parts of the Balkan Peninsula. Vines are variously trained, but since their main roots go deep down into the soil they can be, and often are, grown close together. Olives, on the other hand, have a superficial and very extensive root system, and have therefore to be planted at considerable distances apart. Sometimes other crops are planted between the olive-trees; frequently the spaces are not cultivated but are more or less overgrown by natural or weed vegetation. Thus on the South Dalmatian coast I have botanized in olive-groves which had many stages of degenerate macchie forming their 'weed' flora. It follows that a large majority of the species of the Dalmatian flora of the coastal districts may be found in olive-woods.

Explanations of tables. It is somewhat difficult to know where to draw the line, and what to define strictly as weeds. I therefore give a twofold account. In the first table I have included all species which have been recorded from the habitats in question, though they may and often do occur in other habitats as well, and may not be at all typical 'weeds' or 'ruderals'. In addition to this I have attempted to give an account of the true, typical weed and ruderal flora, and with this is associated a second table.

In Table I, the first column includes weeds of arable land; the second, weeds of vineyards; the third, weeds of olive-groves; the last, ruderals. The Balkan Peninsula has been divided up into 24 districts as follows: 1. Crete. 2. Greece. 2a. Cyclades. 3. Thessaly. 4. Epirus. 4a. Corfu. 5. Albania. 6. North Macedonia. 6a. South Macedonia. 6b. Athos Peninsula. 7. Thrace. 7a. Imbros, Lemnos, and Samothrace. 8. North Bulgaria. 8a. South Bulgaria. 8b. Rodope massif. 9. Dobruja. 10. Serbia. 10a. Sandjak of Novi Pazar. 11. Montenegro. 12. Bosnia. 13. Hercegovina. 14. Dalmatia. 15. Croatia. 16. Istria. Of these 2a, 4a, 6b, 7a, 10a, are considered in a special sense as minor districts, the rest as major ones. For the Balkan Peninsular distribution as given in Table II, those species are counted under the headings:

Very wide (V.W.) which occur in all districts, or in all except the minor ones and one major one.

Wide (W.) which occur in all but two, three, or four of the major districts.

Limited (L.) which occur in four or more districts, but are absent from five or more major ones.

Very limited (V.L.) which occur in only one, two, or three districts.

The general distribution of each species has been worked out under the following headings:

I. Cosmopolitan types (in the sense of occurring north and south of the equator and in both the Old and New Worlds). I.a. Old World

types. II. North Temperate types. III. East North Temperate types. IV. General European types. V. Mediterranean Regional types. VI. Mediterranean Basin types. VII. West Mediterranean Basin types. VIII. South European types. IX. Italian types. X. East Mediterranean Basin types. XI. Oriental types. XII. Central European types. XIII. Dacian types. XIV. Pannonian types. XIV.a. Pontic types. XV. Alpine types. XVI. West North African types. XVII. Egyptian types. XVIII. Caucasian types. XIX. Balkan Peninsular types. XX. Endemics. In Table II, for the General Distribution there are counted under the heading:

Very wide (V.W.) those species determined as I, I.a, II, or III.

Wide (W.) those species determined as IV, V, or VI, and most combinations.

Limited (L.) those species determined as VII, VIII, IX, X, XI, XII, XIII, XIV, XIV.a, XV, or XVI, and a few combinations.

Very limited (V.L.) those species determined as XVII, XVIII, XIX, or XX.

ANALYSES OF THE TABLES.

The following families in the order in which they are given, are, on the basis of numbers of species, the most important contributors to the weed and ruderal floras: *Compositae*, *Leguminosae*, *Cruciferae*, *Umbelliferae*, and *Gramineae*.

A more detailed analysis of the contribution of each family is now given:

Gramineae. Of the typical weeds of arable land all, except 3 perennials, are annuals, though 4 of these are sometimes biennials, and 1 often behaves as a perennial. Two species call for special mention: *Apera interrupta* P. Beauv. is recorded from Serbia and S. Croatia, but since I have seen no specimens from the Balkan Peninsula, I am doubtful if these records should be included. *Lolium compressum* Boiss. et Orph. is placed by Halácsy as a var. of *perenne* and by Boissier in the *Flora Orientalis* as a var. of *rigidum*, but it is morphologically distinct from both, has a compact geographical distribution, and for the present must be retained as a species.

With regard to the 'limited' species within the Balkan Peninsula, there is no doubt that some of them would be placed in the 'wide' group if collecting had been more complete, since many of them are on the border line. Even allowing for this it is obvious that on the whole the general distribution is relatively wider than that within the Balkan Peninsula. A number of species which have been recorded in arable land are certainly not to be regarded as normal weeds and have not been included in the detailed table and the above notes.

TABLE I.

	Arable land	*Vineyards*	*Olive groves*	*Ruderals*
Gramineae	36	2	2	22
Cyperaceae	1	1	..	..
Araceae	..	..	2	..
Liliaceae	25	6	6	..
Amaryllidaceae	..	2	..	..
Orchidaceae	..	..	1	..
Monocotyledons	62	11	11	22
Urticaceae	..	..	..	8
Santalaceae	3	..	..	..
Aristolochiaceae	2	1	..	..
Polygonaceae	11	..	1	10
Chenopodiaceae	17	2	..	23
Amarantaceae	5	..	..	7
Cynocrambaceae	1	..	1	1
Phytolaccaceae	..	..	..	1
Aizoaceae	1	..	..	3
Portulacaceae	1	..	..	..
Caryophyllaceae	28	15	1	6
Ranunculaceae	28	3	1	4
Berberidaceae	1	..	..	..
Papaveraceae	22	6	3	6
Capparidaceae	2	..	..	2
Cruciferae	43	6	5	40
Resedaceae	3	2	..	1
Rosaceae	3	2	..	2
Leguminosae	74	10	7	24
Geraniaceae	1	..	..	2
Oxalidaceae	2	..	1	2
Linaceae	1	..	1	2
Zygophyllaceae	2	..	..	2
Rutaceae	1	..	..	2
Euphorbiaceae	21	6	3	8
Rhamnaceae	..	1	..	..
Malvaceae	9	1	1	11
Hypericaceae	..	1	1	..
Tamaricaceae	..	1	..	..
Violaceae	2	1	..	..
Thymelaeacaceae	2	..	..	..
Lythraceae	1	..	..	..
Umbelliferae	37	16	9	10
Primulaceae	3	..	..	1
Plumbaginaceae	1	..	..	1
Asclepiadaceae	..	..	..	1
Convolvulaceae	2	..	..	..
Borraginaceae	19	6	..	15
Verbenaceae	..	..	..	2
Labiatae	24	3	3	17
Solanaceae	3	..	..	7
Scrophulariaceae	30	8	1	6
Orobanchaceae	7	..	..	..
Acanthaceae	2	1	..	1
Plantaginaceae	4	..	..	..
Rubiaceae	10	4	1	1
Valerianaceae	10	..	..	..
Dipsacaceae	7	1	2	3
Cucurbitaceae	..	..	..	1
Campanulaceae	6	..	..	..
Compositae	105	27	7	68
Dicotyledons	558	124	49	301
TOTAL PHANEROGAMS	620	135	60	323

TABLE II.

Family	*Weeds of arable land*								*Ruderals*							
	B.P. distribution				*General distribution*				*B.P. distribution*				*General distribution*			
	V.W.	*W.*	*L.*	*V.L.*	*V.W.*	*W.*	*L.*	*V.L.*	*V.W.*	*W.*	*L.*	*V.L.*	*V.W.*	*W.*	*L.*	*V.L.*
Gramineae	5	9	21	2	21	14	1	1	4	5	6	1	12	2	1	1
Cyperaceae	..	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..
Liliaceae	2	3	5	6	1	11	2	2	..	..	..	..	..	..	..	..
Urticaceae	..	4	3	1	2	3	2	1	..	..	..	..	..	..	..	..
Aristolochiaceae	..	..	1	1	..	1	..	1	..	..	..	..	..	..	..	..
Polygonaceae	5	1	3	2	8	1	1	1	3	1	3	3	7	1	1	1
Chenopodiaceae	1	4	11	1	15	1	1	1	5	16	1	21	1	1	..	..
Amarantaceae	1	1	3	..	5	1	1	5	..	..	..	7	..	..	..	..
Cynocrambaceae	..	..	1	..	..	1	..	..	..	..	1	..	..	1	..	..
Phytolaccaceae	..	..	..	..	..	..	..	..	..	..	1	..	1	..	..	..
Aizoaceae	..	..	1	..	1	..	..	..	..	..	2	1	2	1	..	..
Portulacaceae	1	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..
Caryophyllaceae	5	2	14	7	11	11	2	4	..	2	1	3	1	2	3	..
Ranunculaceae	1	4	14	7	2	17	6	1	..	..	2	1	2	1	..	..
Berberidaceae	..	..	1	..	..	..	1	..	..	..	..	..	..	..	..	..
Papaveraceae	2	..	17	3	5	12	5	..	1	..	2	3	1	4	1	..
Capparidaceae	..	..	2	..	..	1	..	1	..	..	2	..	..	1	..	1
Cruciferae	3	8	21	9	5	20	11	5	3	8	21	8	7	18	11	4
Resedaceae	..	..	1	2	..	1	2	..	..	..	1	..	..	1	..	..
Rosaceae	..	1	..	..	1	..	..	..	..	1	..	..	1	..	..	..
Leguminosae	3	12	40	14	5	44	14	6	2	1	14	7	7	11	5	1
Geraniaceae	..	1	1	..	1	1	..	..	..	..	2	..	..	2	..	..
Oxalidaceae	..	1	..	1	1	1	..	..	..	1	..	1	1	1	..	..
Linaceae	..	..	..	..	..	..	..	..	..	..	1	..	..	1	..	..
Zygophyllaceae	1	..	1	..	1	..	..	..	1	..	1	..	1	..	..	..
Euphorbiaceae	3	4	11	3	3	11	6	1	1	3	4	..	2	5	1	..
Malvaceae	1	2	3	2	1	5	2	..	2	2	6	1	3	6	2	..
Violaceae	..	..	2	..	..	1	1	..	..	..	..	..	..	..	..	..
Thymelaeaceae	1	..	..	1	1	1	..	..	..	..	..	..	..	..	..	..
Lythraceae	..	1	..	..	1	..	..	..	..	..	..	..	..	..	..	..
Umbelliferae	5	2	23	7	4	19	12	2	1	3	6	..	2	8	..	..
Primulaceae	2	..	1	..	2	..	1	..	..	..	..	1	..	..	1	..
Asclepiadaceae	..	..	..	..	..	..	..	..	..	..	1	..	..	1	..	..
Convolvulaceae	1	..	1	..	1	..	1	..	..	..	..	..	..	..	..	..
Borraginaceae	4	2	10	3	4	4	8	3	3	3	8	1	3	6	5	1
Verbenaceae	..	..	..	..	..	..	..	..	1	..	1	..	1	1	..	..
Labiatae	2	1	16	4	5	6	11	1	5	1	5	6	5	3	6	3
Solanaceae	2	..	..	1	2	1	..	..	2	1	2	2	4	2	1	..
Scrophulariaceae	2	3	18	7	5	13	6	6	..	3	2	1	1	2	3	..
Orobanchaceae	..	..	6	1	2	4	1	..	..	..	..	..	..	..	..	..
Acanthaceae	..	..	2	..	..	1	1	..	..	..	1	..	..	..	1	..
Plantaginaceae	1	2	1	..	2	2	..	..	..	..	..	..	..	..	..	..
Rubiaceae	1	2	5	2	1	4	3	2	..	..	..	..	..	..	..	..
Valerianaceae	..	2	6	2	..	7	3	..	..	..	..	..	..	..	..	..
Dipsacaceae	..	1	4	2	1	3	2	1	..	1	1	1	..	1	2	..
Cucurbitaceae	..	..	..	..	..	..	..	..	..	..	1	..	..	1	..	..
Campanulaceae	1	..	4	1	1	3	2	..	..	..	..	..	..	..	..	..
Compositae	13	9	57	24	17	41	29	16	9	12	37	10	16	29	14	9
TOTALS.	69	82	332	116	140	267	138	61	43	64	136	79	81	113	58	21

Of the ruderals 13 species are annuals, though 1 of these is sometimes biennial and another is often perennial. Three species are definitely perennial. *Cynodon dactylon* Pers. is an interesting species. It is extremely abundant in most of the districts and has a greater vitality than any other plant I know. In South Macedonia it used to penetrate through the hard trodden floors of our tents in relatively permanent camps.

Cyperaceae. The only species occurring as a weed in arable land is *Cyperus rotundus* L., a perennial plant which is practically cosmopolitan in warm regions and whose distribution is limited in the Balkan Peninsula to the Mediterranean domain.

Liliaceae. The 25 species recorded as weeds in arable land are all perennials, and geophytes. While a few, as *Muscari comosum* Mill., are extremely common, most of the species, in my experience, occur on ground left fallow, rather than amongst crops as characteristic weeds. One endemic species, *Tulipa boeotica* Boiss. et Heldr., has been somewhat doubtfully included here. Not more than 6 or 7 species can be said to be of common occurrence in arable land, while only 16 species are really entitled to the designation 'weeds' of cultivated arable ground.

Urticaceae. All the 4 species of *Urtica* are ruderals and are, indeed, the most typical of 'camp-followers'. Three of them are annuals and 1 is a perennial. Within the Balkan Peninsula 2 of them are wide in distribution (probably very wide) and 2 limited (to the warmer parts). In general distribution, 2 are very wide and 2 limited. Both of the latter are Mediterranean Basin types, though 1 extends to the Caucasus. It is interesting to note that *U. dioica* L. apparently does not occur in Crete. The 4 species of *Parietaria* are also included as partly ruderals since they occur on walls, even more than in natural habitats. They are all perennials. *P. cretica* L. is very limited both in its Balkan Peninsular and in its general distribution. Of the remaining 3 species 2 are of wide and 1 of limited distribution, within the Peninsula, but all 3 are of wide general distribution.

Santalaceae. Three species of *Thesium* occur as weeds in arable land, especially when this is left fallow. They are of little importance in this connexion.

Aristolochiaceae. Two species of *Aristolochia* occur in fields and 1 in vineyards. Of the former *A. bodamae* Dingler is a very limited endemic, while *A. longa* L. is limited within but wide in its distribution outside the Balkan Peninsula. *A. clematitis* L. is wide within and very wide in its distribution outside the Balkan Peninsula. All are perennials.

Polygonaceae. Of the weeds in arable land 4 are definitely perennials and 5 annuals, while 1 may behave as annual or biennial, and another

as annual or perennial. Of the ruderals 2 are annuals, 7 perennials, and 1 may either be annual or biennial. *Rumex nepalensis* Spreng., *Syst.* ii. 159 (1825), has an interesting distribution. A specimen at Kew, collected by Haussknecht near the Korona monastery, agrees exactly with Himalayan material. The species is also recorded from the Galičica Planina, between lakes Ochrida and Presba, in Macedonia. In its general distribution the species is known from Asia Minor (Lydia, Cilician Taurus, &c.), the Lebanon, the Temperate Himalayas, Western Indian Peninsula, China, Java, and South Africa. It is recorded as an alien in Britain near the Gala and Tweed.[1]

Chenopodiaceae. This family supplies 17 species as typical weeds of arable land. 15 of these belong to the genera *Atriplex* (2) and *Chenopodium* (13), and all are annuals except 2 species which are perennials. Of the 23 ruderals 6 belong to *Atriplex* and 15 to *Chenopodium*. All are annuals except 2 which are perennials.

The predominance of species under 'L.' in the Balkan Peninsular distribution and under 'V.W.' in the General distribution caused me to investigate the figures more closely, and I think the following reasons account for the data given in the tables:

1. Further collecting will certainly lead to about 4 species being moved from L. to W. in the Balkan Peninsular distribution.

2. The limiting factors for about 5 species are obviously connected with the Central European and Mediterranean types of climate.

3. A further subdivision between W. and L. would reduce the species under L. by about half in the Balkan Peninsular column.

Amarantaceae. The 5 species of weeds of arable land and the 7 ruderals are all annuals, except *Amarantus deflexus* L. which is perennial, and is both a weed and a ruderal. They are mostly late flowering, *A. deflexus* L. from May to September, the rest from July to September, or October. Most, if not all, of the species are of American origin, though now very widely distributed in warmer regions. *Amarantus albus* L. is of North American origin and has been spreading in Central and Southern Europe since about 1880.[2] Since it affords an excellent example of the spread of an alien plant as a weed and ruderal I have carefully traced all I could of the records for the Balkan Peninsula. Halácsy [*Consp.* iii. 37 (1904)] quotes *A. albus* from Cephalonia (Dall.). In Dallaporta, *Prospetto d. Piante di Cefalonia* (1821), the only reference I find to the species is on p. 122, where it is said 'oltre all' Amaranthus Blitum che si coltiva nelle nostre ortaglie, e s'usa generalmente a titolo di alimento, se ne veggono introdotte da pochi anni in quà nella mia Patria alcune altre specie, che tutte s'usano come

[1] Hayward and Druce, *The Adventive Flora of Tweedside*, 212 (1919).

[2] See *Aschers. u. Graebn. Syn.* v. i. 283–7 (1914).

alimentari. Tali sono l'Amaranthus Albus, l'Amaranthus Tricolor, l'Amaranthus Oleraceus, ec.' Boissier [*Fl. Or.* iv. 990 (1879)] quotes the species from the Peloponnesus (herb. Fauché), but I have not found it recorded in the publications of the French Expedition to the Morea (1832–8). Heldreich [*Flore de l'Île de Céphalonie*, 62 (1882)] records the plant 'in hortis prope Spilaeà Hagii Gerasimi' (Argostoli). Halácsy [l.c. and Suppl. i. 93 (1908)] records it from Attica: pr. Athenas (Heldr.), pr. Trakones, and from Euboea: mt. Telethrion. Marchesetti (1896–7) and Pospichal (1897) record it from Farneto, Monfalcone, and near Trieste. Formanek collected it in 1897 in Thessalia: pr. Lamiam (see Vandas). Maire (1908) also records it from near Larissa. Jurišić (1923) records it from about the village of Udova above the railway station of Strumitza. The spread of *A. albus* in Bulgaria during the last few years has been remarkable. The species is not given by Velenovský [*Fl. Bulg.* (1891) and Suppl. (1898)]. Stoyanoff and Stefanoff in their 'Liste' (1921) record it from Burgas, but in their Flora (1924) they say it is a spreading weed, which, as a ruderal, now grows in nearly all Bulgaria. Urumoff (1925) records it from the Pleven (Plevna) district, Čiflik, Klimentin, Karagui, Teliš, Martvica, Komarev, Učindol, Čarven Breg, Lukovit, Rakit, Vratsa, Bojčinovči, Ferdinand, and Berkoviča, and from Banki near Sofia.

Cynocrambaceae. The one species, *Thelygonum cynocrambe* L., is an annual frequently occurring on walls and also as a weed.

Phytolaccaceae. The one species in the Balkan Peninsula, *Phytolacca americana* L., is of North American origin, and is a perennial, occurring as a ruderal.

Aizoaceae. All the species of the Balkan Peninsula are annuals. In addition to the 2 species of *Mesembryanthemum* distributed from Crete or Greece to Dalmatia, *M. cooperi* Hook. f., a native of South Africa, is said by Maire (1921) to have become naturalized on the shore at Phalerus.

Portulacaceae. The one species, *Portulaca oleracea* L., occurring as a weed, is an annual.

Caryophyllaceae. The 28 species of weeds of arable land are all annuals except one, which is perennial, and another which is definitely biennial, but 4 of them sometimes behave as biennials. The genus *Silene* contributes 11 species. It is of interest to note that 3 of the species, *Dianthus tripunctatus* S. et S., *Silene reinholdii* Heldr., and *S. remotiflora* Vis., are endemics. Of the 6 ruderals, all are annuals, but 2 may also behave as biennials.

Ranunculaceae. Two of the species recorded from arable land cannot be regarded as typical weeds and are not included in the second table. Of those left 21 are annuals, and 5 perennials. 9 species of *Ranunculus*,

6 of *Delphinium*, and 5 of *Adonis* are included in the total. *Delphinium brevicorne* Vis. is endemic to the Ionian islands and Dalmatia. 3 species are here accepted as ruderals, all of them annuals.

Berberidaceae. The perennial *Leontice leontopetalum* L. is found as a weed in the southern Mediterranean parts of the Balkan Peninsula, and is distinctly of Oriental distribution.

Papaveraceae. Species of this family include 22 very typical weeds of arable land. All of them are annual including 10 species of *Fumaria* and 7 of *Papaver*. An interesting feature of the distribution is the limitation of many species to the Mediterranean domain within the Balkan Peninsula, and of a few nearly to the Central European domain. Only two species are known to be very widely distributed within our area, but probably a few more will ultimately have to be added to this category. The 6 species occurring as ruderals are all annuals. In addition *Papaver somniferum* L. is much cultivated, and occasionally I have seen it persisting as a weed or ruderal for one or two seasons but not extending its distribution. *Fumaria petteri* Reichb. is endemic to Dalmatia.

Capparidaceae. Capparis sicula Duh. is a dwarf shrubby perennial, which occurs in derelict fields, on walls, and on rocks. *Cleome aurea* Čel. is an annual, endemic to the Balkan Peninsula, but occurs in 5 districts.

Cruciferae. Two of the 43 species recorded as weeds of arable land are not included here. 32 species are annuals, 4 perennials, 3 biennials, 1 behaves as annual or perennial, and 1 as annual or biennial. It is noteworthy as indicating how the genera of *Cruciferae* have been split that 34 genera are represented. *Erysimum graecum* Boiss. et Heldr. and *Nasturtium thracicum* Griseb. are endemics to the Balkan Peninsula. Of the 40 species occurring as ruderals 23 are annuals, 6 biennials, 8 perennials, 2 behave as annuals or biennials and 1 as an annual or a perennial. *Capsella grandiflora* Boiss. and *Erysimum graecum* Boiss. et Heldr. are endemics to the Balkan Peninsula. Both amongst the weeds and the ruderals many of the annuals are more exactly designated as ephemerals, since their seeds germinate and the plants flower and fruit within a few weeks, sometimes giving several generations in a year. Thus, in 1925, between April and October I raised two generations of *Vella annua* L. out-of-doors, and without giving special attention, while in a greenhouse I could with ease have raised four generations in a year.

Resedaceae. Two species of weeds (*Reseda jacquinii* Reichb. and *R. truncata* Fisch. et Mey.) are annual and *R. alba* L. is biennial or perennial. The 1 ruderal (*R. phyteuma* L.) is annual.

Rosaceae. Only 1 species, *Potentilla argentea* L., can be regarded as an arable land weed and as a ruderal. It is perennial.

Leguminosae. This family contributes more species to the weed flora of arable land than any other except the *Compositae.* Of the species counted in the first table 5 are omitted from the second table and from consideration here. The remaining 69 species have the following duration: 60 annual, 2 biennial, and 7 perennial. *Astragalus graecus* Boiss. et Sprun., *Lathyrus grandiflorus* S. et S., *Lathyrus quadrimarginatus* Ch. et B., and *Lupinus graecus* Boiss. are endemic to the Balkan Peninsula. Of the 24 ruderal species 14 are annual, 3 biennial, and 7 perennial. *Trifolium thessalonicum* Hal. et Char. is endemic to the Peninsula. For both the weeds of the arable land and the ruderals the importance of the climatic limiting factors is emphasized by the fact that many species are nearly or quite confined to either the Mediterranean or Central European domain.

Geraniaceae. One species of weed (*Erodium cicutarium* L'Hér.) is annual; the other (*E. romanum* L'Hér.) is perennial. The 2 ruderals (*E. malacoides* Willd. and *E. moschatum* L'Hér.) are both annuals.

Oxalidaceae. Both species (*Oxalis cernua* Thunb. and *O. corniculata* L.) are perennial. *O. cernua* Thunb., occurring as a weed and ruderal in Crete, Greece, and Corfu, originated from South Africa.

Linaceae. The species are annual. *Linum usitatissimum* L. occurs as a relict of and an escape from cultivation and is not counted here.

Zygophyllaceae. Of the 2 species occurring both as weeds and ruderals *Tribulus terrestris* L. is annual and *Peganum harmala* L. perennial.

Rutaceae. Both species (*Ruta buxbaumii* Poir. and *R. suaveolens* DC.) are perennials and neither of them is a typical weed or ruderal.

Euphorbiaceae. Of the 21 weeds of arable land 5 are perennials and the rest annuals. *Euphorbia zahnii* Heldr. is endemic to southern Greece. The genus *Euphorbia* accounts for 17 species, most of them very typical weeds. Of the ruderals 2 are perennials and 6 annuals.

Malvaceae. Of the 8 weeds of arable land 6 are annuals, 1 is a biennial, and 1 behaves either as an annual or a biennial. The ruderals are represented by 7 annuals, 2 biennials, and 2 perennials. *Malva silvestris* L. occurs in every major and every minor district and is one of the commonest ruderals of the Balkan Peninsular flora.

Violaceae. Viola kitaibeliana R. et S. is widely spread as a weed of arable land.

Thymelaeaceae. Two annual species of *Lygia* (*L. passerina* Fasan. and *L. pubesceus* Boiss.) are recorded from arable ground.

Lythraceae. The annual species, *Lythrum hyssopifolium* L., occurs in arable land.

Umbelliferae. Of the 37 weeds of arable land 23 are annuals, 3 biennials, 10 perennials, and 1 may be either biennial or perennial.

Carum velenovskyi Rohl. from Montenegro, and *Hippomarathrum pauciradiatum* Hal. from the Cyclades, are endemics. A number of species of *Eryngium* and *Bupleurum*, not included here, occur in fields left fallow or derelict for several years, as I saw near the Struma Plain in 1917. It is also interesting to note that 16 and 9 species respectively are recorded for vineyards and olive-groves, and this most probably far from exhausts those occurring in such habitats. Of the 10 ruderals 6 are annuals, 3 biennials, and 1 a perennial.

Primulaceae. The 3 weeds and the 1 ruderal are all annuals. The ruderal, *Anagallis platyphylla* Baudo, was probably introduced with army fodder from North Africa.

Plumbaginaceae. The 1 species (*Limonium sinuatum* Mill.) recorded as a weed is not typically such.

Asclepiadaceae. The perennial *Gomphocarpus fruticosus* R.Br. occurs in waste places in the Mediterranean domain.

Convolvulaceae. Both the weeds (*Convolvulus arvensis* L. and *C. hirsutus* Stev.) are perennial.

Borraginaceae. Eleven of the 19 arable land weeds are annuals, 4 are biennials, and 4 perennials. *Nonnea atra* Griseb. and the doubtful *Onosma proponticum* Aznav. are endemics. The family is often well represented in fallow land in the Mediterranean domain. 7 of the 15 ruderals are annuals, 5 biennials, 2 perennials, and 1 either biennial or perennial. None is endemic.

Verbenaceae. Of the 2 ruderals, *Verbena supina* L. is annual, *V. officinalis* L. perennial.

Labiatae. One of the species recorded as a weed is certainly not typically such and is not included here and in the second table. 14 weeds are annuals, 8 perennials, and 1 probably behaves sometimes as an annual, sometimes as a perennial. The family contributes important species both to the earlier and later flowering weed-flora. Of the ruderals 6 are annuals and 11 perennials. *Ballota pseudodictamnus* Benth. and *Nepeta scordotis* L. are endemic to Crete, and *Stachys serbica* Panč. to the mainland of the Peninsula (Pindus, North Macedonia, South Bulgaria, and Serbia).

Solanaceae. Of the weeds 1 is annual and 2 are perennial herbs. Of the ruderals 3 are annual, 1 is a perennial herb, and 1 a sprawling shrub, 1 either annual or biennial, and 1 either annual or a perennial herb. The absence of records for *Hyoscyamus niger* L. from Albania and Dalmatia is curious. In the latter district *H. albus* L. is a very common and abundant ruderal. *Datura tatula* L. is recorded only for Dalmatia in the Balkan Peninsula.

Scrophulariaceae. Of the weeds 23 are annual, 5 biennial, and 2 perennial. It is of importance to note that 18 are limited and 7 very

limited in their Balkan Peninsular distribution. *Verbascum pancicii* Rohlena is endemic to Albania and Montenegro, *V. pulchrum* Vel. to Thrace, North and South Bulgaria, and the Dobruja, *V. thracicum* to South Bulgaria, *Veronica glauca* S. et S. to Crete and Greece, *V. peloponnesiaca* Boiss. et Orph. to Greece, Thessaly, Epirus, and Corfu, and *V. pumila* Clarke (*V. pontica* Vel.) to Thrace, North Bulgaria, and South Bulgaria. The genus *Veronica* includes 11 species of typical weeds, *Linaria* 7, and *Elatinoides* 4. Of the ruderals 3 are annual, 2 biennial, and 1 perennial.

Orobanchaceae. The 3 annual and 4 perennial species of weeds are all holoparasites.

Acanthaceae. The species are all perennial and mainly limited to the Mediterranean and transitional districts.

Plantaginaceae. Two species are annual, 2 perennial.

Rubiaceae. Of the 10 species of weeds 8 are annual, 1 is perennial, and 1 annual or biennial. 6 species of *Galium* are represented of which *Galium capitatum* Bory et Chaub. is endemic to Greece and Thessaly and *G. incrassatum* Hal. to Crete. The one species recorded as a ruderal is not typically such.

Valerianaceae. All 10 species of weeds are annuals.

Dipsacaceae. Of the weeds 3 are annual, 2 biennial, 1 perennial, and 1 biennial or annual. *Knautia byzantina* Fritsch is recorded only from Thrace in the Balkan Peninsula but occurs also in Bithynia. Of the ruderals 2 are biennial and 1 is perennial.

Cucurbitaceae. The typical ruderal *Ecballium elaterium* Rich. is generally a perennial in the Balkan Peninsula.

Campanulaceae. Five of the weeds are annual and 1 is biennial. Two are species of *Campanula* and 4 of *Legousia.*

Compositae. This family contributes more species to the weed flora of arable land than any other. 103 species are accurately considered as weeds and are counted here. Of these 53 are annual, 21 biennial, 26 perennial, 2 annual or biennial, and 1 annual or perennial. The following species are endemic to the Balkan Peninsula: *Anthemis guicciardii* Heldr. et Sart. (Greece, Cyclades), *Carlina graeca* Heldr. et Sart. (Greece, Cyclades, Thessaly, Albania, South Macedonia, Thrace, Thracian islands), *Carthamus ruber* Link (Crete, Greece), *Centaurea guicciardii* Boiss. (Greece, Cyclades, Epirus, Albania), *C. idaea* Boiss. et Heldr. (Crete), *C. immanuelis-lowii* Degen (South Macedonia, Athos Peninsula), *C. minoa* Heldr. (Crete, Greece), *C. orphanidea* Heldr. et Sart. (Greece, Thessaly, South Macedonia), *C. spruneri* Boiss. et Heldr. (Greece), *C. tuntasia* Heldr. (Greece), *Chondrilla ramosissima* S. et S. (Crete, Greece, South Macedonia), *Echinops graecus* Mill. (Crete, Greece, Cyclades, Thessaly), *E. oxyodontus* Bornm.

et Diels (North Macedonia), *E. thracicus* Vel. (South Bulgaria), and *Evax perpusillus* Boiss. et Heldr. (Greece). That 7 of these 15 species belong to the genus *Centaurea* is correlated with the fact that this genus is the largest of those placed in the family and, indeed, of the genera of Phanerogams in our flora. Most of the species mentioned above are morphologically easily distinguishable. Thus *Centaurea immanuelis-lowii* is a most conspicuous plant, which I collected in cornfields in 1917 south of the Krusa Balkan. Six of the above species are at present only known from one district. Of the 68 ruderals 36 are annual, 18 biennial, 13 perennial, and 1 either annual or biennial. The following species are endemic to the Balkan Peninsula: *Anthemis peregrina* L. (Greece, Cyclades, Thessaly, South Macedonia, Thrace, Montenegro), *Carduus marmoratus* Boiss. et Heldr. (Thrace), *Centaurea orphanidea* Heldr. et Sart. (Greece, Thessaly, South Macedonia), *Centaurea varnensis* Vel. (North Bulgaria, Dobruja), *Hymenonema graecum* DC. (Crete, Cyclades), *Onopordon laconicum* Heldr. et Sart. (Greece), *Taraxacum haussknechtii* Uechtr. (Thessaly, Albania, North and South Macedonia, Serbia), and the doubtful *Tragopogon kindingeri* Adamov. (North Macedonia).

The spread of certain species of *Xanthium* in Europe affords a good example of man's unintentional constructive influence on the vegetation. It has been supposed by many botanists that *Xanthium spinosum* L. was introduced from America to Portugal and spread thence, as a naturalized plant, eastwards through all the countries bordering the Mediterranean Basin to the steppe district of South Russia: it now occurs as a casual in most European countries. The discovery of fruits in supposed Neolithic deposits in Bulgaria (Turrill in *Kew Bull.* 1923, 190) has led to doubt being thrown on this view. However, *Xanthium saccharatum* Wallroth subsp. *aciculare* Widder, a native of the northern United States, south-west of the Great Lakes, furnishes us with another example whose future history in Europe will be of great interest. This plant was first collected in Europe by Nadji Effendi (Charrel or Abd-ur-Rahman-Nadji) in 1891, 'marais de Tekelü', about seven miles from Salonika. Bornmüller observed it in 1918, 'in desertis planitiei ad fl. Vardar, inter Hudova et Kalučkova abunde'. Střibrny collected it in arable fields near Sadova in South Bulgaria in 1921. *X. italicum* Moretti, certainly of North American origin, is spreading rapidly in the eastern parts of the Balkan Peninsula, as it has already spread in some of the western.[1]

General Conclusions. From the tables and data given above the following broad facts emerge:

[1] Turrill in *Journ. Bot.* lxii. 240 (1924), and more recent information received from Gilliat-Smith.

1. That both among weeds and ruderals more species come under the heading 'limited' for the Balkan Peninsular distribution and under the heading 'wide' for the General distribution than under any other headings. This is more pronounced for some families than for others, and the explanation is twofold: that for many species the detailed distribution within the Peninsula is relatively less known than the General distribution outside it, and that the Mediterranean and Central European climates have well-marked limiting effects which are better shown for the Peninsular than for the General distribution. A considerable amount of evidence leads to the conclusion that many Mediterranean species can flourish outside the Mediterranean climatic region when competition with other species in closed vegetation is eliminated. Man has introduced many such plants into distant parts of the world, especially with cereals, and under the conditions found in arable land they have become established. Conversely, weeds and ruderals have been introduced from America and other continents into the Balkan Peninsula but have not yet spread beyond districts limited to one or other of the climatic domains.

2. Ignoring those species whose duration is not constantly annual, biennial, or perennial, the typical weed flora consists of 407 annuals 39 biennials, and 121 perennials, and the typical ruderal flora of 172 annuals, 39 biennials, and 77 perennials. The majority of the annuals flower in the spring and early summer, and the later flowering weed and ruderal floras consist mainly of biennials and perennials with the thistle-like *Compositae* well represented.

Origin and distribution of the weeds and ruderals. For the majority of the species of the weed flora it is impossible to decide definitely if they have originated from the native flora or have been introduced by man's activities. There is no doubt that some species of characteristic weeds are really plants native to the Peninsula. Thus, while *Centaurea cyanus* L. occurs as a weed in cereal and other fields, I have collected it amongst hill brushwood (shiblyak and pseudomacchie) in South Macedonia. The species of *Anagallis* again occur as weeds and also as elements in natural vegetation. That 41 species of weeds and 16 ruderals are endemic to the Balkan Peninsula is additional evidence for the local origin of part of the arable land and waste ground floras. On the other hand, it must be remembered that commerce in grain was well developed in very early historic (and possibly even in prehistoric) times. The grain could rarely have been 'clean' on a modern standard and the facilities for weed dispersal must have been very great. Moreover, we have to remember that if ancient Greece imported considerable grain, the Balkan Peninsula as a whole (especially Macedonia and Thracia) exported grain in Roman times

to many other parts of the Roman world. It is possible that the spread of some species of southern types of weeds to Central Europe and even to the British Isles was direct from the Balkan Peninsula. In this connexion it is interesting to note that the common variety of *Cichorium intybus* L. in the Balkan Peninsula is the var. *glabratum* (Presl.) G. et G. This is the variety which is found in old chicken-runs, and similar habitats, in the British Isles. The vast majority of the weeds of arable land found in the British flora (as given in Babington's *Manual*, ed. x) occur also as weeds in the Balkan Peninsula. It is at least probable that the Peninsula has contributed its share to the weed flora of Europe.[1] The weed flora, on the whole, has not had such diverse and world-wide origins as the ruderal flora. Modern commerce has been responsible for the introduction of species from many parts of the world, and these have often found in the Balkan Peninsula conditions favourable for rapid spreading in ruderal situations. Again, the many foreign invasions and the movements of armies have introduced and spread alien plants. Eastern species were left by the Turks even up to the neighbourhood of Vienna. In the late war much army fodder was used in Macedonia from British, French, and Italian possessions. Thus I saw bales of hay consisting largely of *Themeda triandra* Forsk. (*T. forskalii* Hackel). Near Turica, by an artillery camp, I collected a flowering specimen of *Anagallis platyphylla* Baudo, a North African species probably introduced with fodder. Near Durazzo Dörfler collected *Cotula anthemoides* Willd. probably introduced from Africa with Italian military importations. A great many ruderals are of American origin, such as species of *Amarantus*, *Xanthium*, and *Phytolacca*. Yet on the other hand it is interesting to note that the 'Mediterranean' is given as the most important single geographical source of the wool-aliens of both Montpellier and Tweedside, 416 species for the former and 113 for the latter having this origin.[2]

Garden Escapes. Horticulture is a very little developed art in the Balkan Peninsula and the cultivation of exotic plants for their beauty has not led to many species becoming subspontaneous. Even amongst plants cultivated for their economic value few have spread beyond fields and gardens. The olive, I believe, is wild (in at least one of its varieties) in the Mediterranean domain of the Balkan Peninsula. *Vitis vinifera* L. and *Ficus carica* L. are possibly native in some varieties. *Punica granatum* L., *Papaver somniferum* L., and *Broussonetia papyrifera* Vent., which sometimes occur semi-wild, are certainly of extraneous origin. The North American *Robinia pseudacacia* L. has

[1] A paper by Stapledon [*Journ. Bd. Agric.* xxiii. 105 (1916)] is of some interest in this connexion.

[2] Hayward and Druce, *The Adventive Flora of Tweedside*, xxiv. (1919).

spread a great deal, partly spontaneously, in the more northern districts, and the Chinese *Ailanthus altissima* Swingle is spreading rapidly in many places, as around the Bocche di Cattaro, on the south-western slopes of Mt. Lovćen, and in eastern Bulgaria.

Town Ruderals. As an example of town ruderals the following lists are taken from my notebooks: Sofia (13.7.26), *Hordeum murinum* L., *Setaria viridis* Pal. de Beauv., *Urtica dioica* L., *Polygonum aviculare* L., *P. persicaria* L., *Chenopodium album* L., *Amarantus retroflexus* L., *Capsella bursa-pastoris* Medik., *Lepidium ruderale* L., *Sisymbrium officinale* L., *Malva silvestris* L., *Ballota nigra* L., *Datura stramonium* L., *Plantago major* L., *P. media* L., *Cirsium arvense* Scop., *C. lanceolatum* L., *Erigeron canadensis* L., *Lapsana communis* L., *Taraxacum vulgare* Schrank, *Xanthium spinosum* L., and *X. strumarium* L.; Varna (11.8.26), *Echinochloa crus-galli* Pal. de Beauv., *Setaria* spp., *Polygonum persicaria* L., *Amarantus retroflexus* L., *Lepidium ruderale* L., *Malva silvestris* L., *Datura stramonium* L., *Artemisia annua* L. (very abundant), *Xanthium italicum* Mor., *X. spinosum* L., and *X. strumarium* L.

Heldreich has made an interesting comparison between the flora of the Isle of Lero and its associated three small reefs and that of the Acropolis of Athens. The only synanthrope ('camp-follower') in the former was *Urtica pilulifera* L., a few individuals of which were found near a disused lime-kiln established an unknown number of years before. On the Acropolis 106 Phanerogams were collected, of which 24 (23·5 per cent.) were synanthropic plants.

SUMMARY

It has been shown that man has influenced the natural flora of the Balkan Peninsula from very early historic or even prehistoric times, chiefly in a destructive manner. This has been accomplished at the expense of the high woody vegetation and has led to a great extension of brushwood communities and those of stony and rocky ground. This has resulted in the expansion, both in species numbers and in distribution, of many genera suited to such habitats, and a corresponding reduction in the abundance of woodland plants. By draining marshes the marsh and aquatic vegetation has been reduced. New habitats have been provided by agriculture and by the more or less permanent occupation of sites for habitation. Species new to the flora have been introduced by commercial and military activities and some have spread far and wide.

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XI

CULTIVATED CROPS

General. It is proposed here to give only a brief account of agriculture and allied pursuits in the Balkan Peninsula, mainly to emphasize the important relationships between the crops which are cultivated and the climate. The results of such a study reinforce the conclusions regarding the importance of climate as the basic causal factor in the distribution of the natural vegetation. The importance of sheep and goats in the economic life of the peoples of the Peninsula, the practice of transhumance, and certain aspects of agriculture have been dealt with in Chapter X. on the influence of man on the vegetation.

The two main vegetational and floristic domains of the Balkan Peninsula, the Mediterranean and Central European, depend essentially on climate, and correspondingly we find two main types of agricultural development, reflected both in the kinds of crops grown and in the methods of their cultivation. It is necessary to emphasize that climatic influence on agriculture is indirect as well as direct. For example, the quantities of available soil depend at least as much upon climatic conditions as on the nature of the rocks. A further matter of interest is the transition between these two types, and here again a correspondence with the natural vegetation is evident. The most characteristic crop of the true Mediterranean domain is undoubtedly the olive, and the exact distribution of olive cultivation gives us the best boundaries of the Mediterranean cultivation. Cereals and vines are the second and third most important crops in the Mediterranean domain, but since their cultivation extends far beyond the zone of Mediterranean climate, although with modifications in methods, they cannot be used as primary indicators. Essentially cultivation in the Mediterranean domain is intensive, and more laborious than in the Central European domain. Smaller areas are cultivated and the crops are more frequently mixed. Soil and summer moisture are precious assets because of their relative scarcity in many districts. These conditions contrast with the more rapid soil formation, and accumulation, and the summer rainfall of the Central European districts where, with settled political conditions, there have developed more extensive systems of agriculture, though extensive methods were also apparent under the old čiflik (feudal) and zadruga (family clan) systems.

Crops of the Districts. The following is a brief list of the chief cultivated plants of each of the districts of the Balkan Peninsula adopted in this work.

1. *Crete.* Olives, vines (for raisins and wine), carobs, oranges, lemons, figs, quinces, mulberries, pears, apples, tobacco, cotton, maize, wheat, and barley.

2. *Greece.* Maize, wheat, barley, olives, vines (for wine, sultanas, and currants), figs, carobs, oranges, lemons, mandarins (*Citrus nobilis* Lour. var. *deliciosa* Swingle, including 'tangerine oranges'), tobacco, mulberries (largely for silkworm-breeding), cotton, almonds, chestnuts, melons, peas, beans, lentils, chick-peas (*Cicer arietinum* L.), onions, saffron, aniseed, hemp (for fibre and hashish), and madder.

2*a*. *Cyclades.* Olives, figs, maize, barley, wheat, melons, orchard fruits, peas, beans, lentils, and chick peas.

3. *Thessaly.* Wheat, barley, maize, oats, beans, peas, lentils, cotton, tobacco, hemp, fruit-trees, and, near the coast, olives, oranges, and lemons.

4. *Epirus.* Wheat, barley, maize, tobacco, and, near the coast, olives, oranges, lemons, and medlars.

4*a*. *Corfu.* Olives, oranges, lemons, vines, figs, vegetables, and some cereals.

5. *Albania.* Maize, wheat, barley, rye, oats, vines, tobacco, mulberries, cherries, pears, and sumach.

6. *North Macedonia.* Wheat, maize, barley, oats, rice, tobacco, poppy, vines (for wine), melons, apples, pears, plums, apricots, paprika, and beans.

6*a*. *South Macedonia* and 6*b Athos Peninsula.* Wheat, maize, barley, oats, rice, tobacco, vine, poppy (for opium and oil), melons, mulberries, cotton, figs, almonds, plums, cherries, apricots, pears, and paprika. Olives only in a few localities.

7. *Thrace* and 7*a Thracian Islands.* Wheat, maize, barley, rye, oats, canary seed, tobacco, cotton, vines (for wine), mulberries, linseed, sesame, beans, chick-peas, fruit-trees, and olives in a few coastal localities.

8. *North Bulgaria.* Wheat, maize, barley, rye, oats, beans, lentils, vines (for wine), sugar-beet, tobacco, sunflower (for oil), and potatoes.

8*a*. *South Bulgaria.* Maize, wheat, barley, rice, millet, tobacco, poppy, cotton, mulberries, roses (for attar-of-roses), sugar-beet, sunflower, and sesame (the seeds widely used for sprinkling on the top of bread rolls).

8*b*. *Rodope Massif.* Maize, wheat, oats, rye, tobacco, buckwheat, potatoes, melons, vines (for wine), peaches, apricots, mulberries, and almonds.

9. *Dobruja.* Barley, wheat, maize, rye, millet, fruits, haricots and other legumes, rape, and mulberries.

10. *Serbia* and 10*a Sandjak of Novi Pazar.* Maize, wheat, barley,

oats, rye, sugar-beet, hemp, vegetables, plums (for slivovitsa and prunes), vines, tobacco (not important and declining), beans, hemp, mulberries (for silk-worms), melons, and orchard fruits.

11. *Montenegro.* Maize, wheat, barley, oats, rye, potatoes, beans, peas, cabbages, tobacco, vines, plums, pyrethrum (for insect powder), and, near the coast, olives, figs, and pomegranates.

12. *Bosnia.* Maize, wheat, oats, barley, plums (for slivovitsa and prunes, the latter of considerable importance), many vegetables, sugar-beet, flax, hemp, pears, apples, and cherries.

13. *Hercegovina.* Tobacco, maize, wheat, vines, figs, olives, plums, pears, apples, cherries, pomegranates, oranges, many vegetables, flax, hemp, sunflower, and pyrethrum (for insect powder).

14. *Dalmatia.* Vines, olives, maize, wheat, barley, rye, sorghum, millet, oats, melons, mulberries, figs, cherries (for maraschino), potatoes, peaches, pomegranates, oranges, lemons, hemp, vegetables, almonds, and chestnuts.

15. *South Croatia* Maize, wheat, barley, rye, oats, vines, flax, potatoes, apples, plums, cherries, nuts, and vegetables.

16. *Istria.* Vines, olives, figs, maize, wheat, barley, potatoes, buckwheat, orchard fruits, and vegetables.

The lists given above indicate the essential Mediterranean nature of the chief crops in Crete, Greece, the Cyclades, Thessaly, Epirus, Corfu, Albania, Montenegro, Hercegovina, Dalmatia, and Istria; the Central European character of those of North Macedonia, North Bulgaria, the Rodope massif, the Dobruja, Serbia, Bosnia, and South Croatia; and the transitional character of those of South Macedonia, Thrace, and South Bulgaria. That large parts of Albania and Montenegro are also transitional in character is mainly due to factors introduced by high altitudes. The olive, fig, and vine are especially sensitive to altitudinal changes, and the first-named crop does not usually succeed above 600 m. even in Greece.

Altitudinal Zonation. The gradual change in crops with increase in altitude I have studied in several districts, notably in South Macedonia, from South Dalmatia into Montenegro, in Bulgaria, and in Serbia. The more typical Mediterranean cultivated plants are the first to disappear, and these are replaced by increased quantities of wheat, and later barley, then oats, rye, and potatoes. The area of cultivated ground rapidly decreases, with a corresponding increase in dry, stony slopes and brushwood in the hill zone, and of forest and pasturage in the higher zones to the first high mountain zone (pre-alpine), where all cultivation has ceased.

Principal Crops. Of the cereals maize is the most important considering the Peninsula as a whole. Wheat is next in importance and then

barley. Wheat and barley are sometimes sown mixed. Rice is only cultivated in a few of the warmer, swampy areas, as in the Maritsa basin. I have only seen it in cultivation in the South Bulgarian plain and a little in South-West Bulgaria. While some districts, notably North Bulgaria and the Dobruja, can normally export considerable quantities of cereals, other districts have to import to supply the local needs. I have not made a study of the varieties of cereals cultivated, but in 1922 I collected an interesting, but at present unnamed, variety of bearded wheat from the Suva Planina above 1,000 m. Oats and rye are less frequently cultivated than wheat and barley, and sorghum and millet are relatively rare as crops.

The vineyards of the Balkan Peninsula must cover a total of many square miles. Many varieties of grapes are grown, most often for wine-making. Most districts have their local varieties of wine, and in many places the wine-presses are of ancient pattern. In Crete and Greece resin of *Pinus halepensis* Mill. is frequently added to the wine. This practice, which dates from antiquity, is said to preserve the wine. Several excellent kinds of grapes are grown for table use, and in the north-west of the Peloponnese and around the Gulf of Corinth the currant-grapes form a staple product. The last ripen as early as August. A sweet paste or jelly formed from the must, boiled in starch and clarified by the addition of an oily white clay is a popular food. Tender vine leaves are used in cooking and the stems are used as fuel and as winter fodder for domestic animals. The lees of the wine are used in the manufacture of brandy and spirits of wine. The phylloxera pest exists in some parts of the Balkan Peninsula, and I saw a badly attacked vineyard in July 1926 in the Maritsa plain between Philippopolis and Stanimaka.

Olives are cultivated mainly for the oil, which is expressed from their fruits. For many parts of Greece they are the most important crop and are grown in the lowland and hill zones throughout the true Mediterranean domain. In old Greece olive groves were said in 1909 to cover an area of 675 square miles and to consist of about 5,000,000 trees. The silvery grey-green foliage provides a very characteristic colour tint to the landscape where olives are cultivated. The main roots are at relatively shallow depths but horizontally they spread widely. The trees are therefore usually planted a much greater distance apart than, for example, the deep rooted vines, and since they are also light shade casters annual crops of cereals, melons, &c. are sometimes grown between and beneath them. On an average the olive-tree yields a good crop every three to six years. Preserved olives eaten with bread form a main article of food for the poorer classes within the Mediterranean domain.

Figs are widely cultivated, but only in Greece are extensive groves found, the fruit of whose trees is dried to form an article of export. The drying is usually partly by the sun, partly by the application of artificial heat.

Tobacco in many varieties is cultivated almost throughout the Balkan Peninsula. The best crops, however, are found in Macedonia, Thrace, and South Bulgaria. Indeed, tobacco succeeds best and is the best-paying crop in the districts with a transitional climate between typical Central European and typical Mediterranean. Great quantities of tobacco sold as Turkish or Egyptian consist of leaf grown in the Balkan Peninsula, and a very large proportion of that which is exported goes to the United States and Egypt. Excellent accounts of the tobaccos grown in various parts of the Peninsula will be found in the supplement to *The Times* for October 20, 1925. I have smoked locally grown tobacco in most of the chief tobacco growing districts and have noted the following general characteristics: extreme mildness, absence of throat 'tickling', fine aroma, dryness resulting in quick burning and little moisture in the pipe, small quantities of tar products and therefore much less staining of fingers from cigarette smoking than with cigarettes of 'Virginian' tobacco. Greek tobacco is said to contain only 0·78 per cent. of nicotine, compared with the 2·06 to 4·09 per cent. contained in American tobacco. Three factories have recently been established in Bulgaria for the extraction of oil from tobacco seeds (*The Near East and India*, January 14, 1926, p. 53). An excellent large-scale coloured map of the *Oriental Tobacco Regions*, including Turkey, Bulgaria, and Greece, has been prepared by Marco Nestoroff, Volkovitch 16, Sofia, from whom copies can be bought. It is dated 1925.

Pulses of many kinds are grown for local consumption both by human beings and domestic animals. Beans are frequently consumed raw. *Phaseolus vulgaris* L., *P. nanus* L., and *P. coccineus* L. as well as *Dolichos melanophthalmus* DC. are cultivated, and *Vicia faba* L. is a common vegetable. Lentils (*Lens culinaris* Medic.) and chick-peas (*Cicer arietinum* L.) are grown in many parts as field-crops.

Melons and other members of the cucumber and marrow family flourish exceedingly, especially in the warmer parts. At Trieste and Salonika (and doubtless at many other ports) huge barge-loads of magnificent fruits come from the adjacent coasts and islands in the season, and there is a very considerable local trade in this commodity. The chief varieties grown of this class of fruit are generally classified under the following specific names: *Citrullus vulgaris* L., *Cucumis melo* L., *Cucumis dudaim* L., *Cucumis sativus* L., *Lagenaria vulgaris* Ser., *Cucurbita pepo* L., and *Cucurbita maxima* Dueh.

Sugar-beet, sunflowers, onions, and buckwheat are cultivated as

important field-crops in different districts. The cultivation of the sugar-beet was extending up to 1924 within the Central European domain (see *La Bulgarie*, June 29, 1926). Poppy (for opium and oil) is a remunerative crop in Macednoia and Serbia, and the opium obtained is said to be of exceptional value for medicinal use. Paprika (varieties of *Capsicum annuum* L.) is universally cultivated and used as a culinary ingredient in many ways in the Slav and northern Greek parts of the Peninsula. The inhabitants affirm its digestive and stimulating value, but delight in its taste has usually to be acquired by a West European. Cotton is cultivated in the warmer lowlands, notably in the Lake Copais, Struma and Maritsa plains. Hemp is widely cultivated, generally for local use of the fibre. Hashish (the dried leaves for smoking and use as a drug) is only exported in small quantity from southern Greece. Mulberries (both black and white) are widely grown, mainly for the use of the leaves in silkworm rearing. Yugoslavia was said in 1924 to be the third largest raw silk-producing country in Europe (see *The Near East*, September 4, 1924, p. 250).

We come now to fruit-growing of the orchard kind. As I have elsewhere indicated parts of the Balkan Peninsula could become the greatest fruit exporting region of Europe if capital were devoted to the introduction of suitable varieties and to the training of workers and development of transport. The climate and soil conditions over wide areas are eminently suitable to the production of the finest crops in great quantities. I see no reason why fresh fruits of plants mentioned already—figs, grapes, melons—and of the grove and orchard fruits now especially referred to could not be placed in bulk on the European markets from the Balkan Peninsula. My wife and I have certainly had many a delicious meal of fruit costing the equivalent of a few English pence. Oranges and lemons are of course exported in bulk from Crete and Greece and are grown locally far up the Adriatic and Aegean coasts. Carobs and pomegranates are grown also in Crete and Greece. Peaches, apricots, plums, cherries, and pears are widely grown. Apples are decidedly inferior in size and taste, and a great many of the other fruit-trees are often little removed from their wild prototype. Cherries are much grown in Dalmatia to yield the liqueur known as maraschino. Plums are an important item of export in the dried form of prunes from Serbia and Bosnia. The famous plum-brandy, or slivovitsa, is also made and consumed in great quantities.

Lastly reference must be made to the peculiar cultivation of roses for the production of attar (otto) of roses. This industry is practically limited to the Kazanlik and Karlovo districts in the valley between the the Balkan and Sredna Gora mountains. Red and white roses are distilled, on an average the former producing about twice as much as the

latter. Excellent accounts of the industry are given in J. C. Sawer, *Rhodologia* (Brighton, 1894), in Gildemeister and Hoffmann, *The Volatile Oils*, ii. 550. (1900), by M. J. Gravereaux in *Bull. du Ministère de l'Agric.*, Paris, 1901, No. 3, in *The Near East* for July 31, 1924, and by A. Zlataroff, *La rose et l'industrie de l'essence de roses en Bulgarie*, Sofia, 1926. The roses cultivated are generally considered to be varieties of *Rosa damascena* Mill. and of *R. alba* L. The total value of the produce varies greatly, but in some years it is said to be second in the list of values of exports from Bulgaria.

XII

FLORISTIC AND PHYTOGEOGRAPHICAL DATA SUMMARIZED FOR THE FAMILIES OF THE BALKAN PENINSULAR PHANEROGAMS

GENERAL.

The families of *Phanerogamae* or *Embryophyta Siphonogama* represented in the flora of the Balkan Peninsula number 126. Those with most genera are: *Compositae* 100, *Gramineae* 99, *Umbelliferae* 82, *Cruciferae* 65, *Leguminosae* 49, *Labiatae* 36, *Caryophyllaceae* 35, *Liliaceae* 31, *Scrophulariaceae* 27, and *Borraginaceae* 26. There are 47 families with only one genus each, and of these 24 have each only one species. The unigeneric families with most species are *Violaceae*, with *Viola* represented by 58 species, and *Hypericaceae*, with *Hypericum* represented by 52 species. The twenty-one largest families, as based on the number of species, are: *Compositae* 913, *Leguminosae* 545, *Caryophyllaceae* 418, *Labiatae* 371, *Gramineae* 358, *Cruciferae* 344, *Umbelliferae* 334, *Scrophulariacae* 311, *Liliaceae* 248, *Ranunculaceae* 195, *Rosaceae* 188, *Borraginaceae* 155, *Campanulaceae* 144, *Cyperaceae* 140, *Rubiaceae* 129, *Orchidaceae* 97, *Dipsacaceae* 83, *Euphorbiaceae* 79, *Iridaceae* 61, *Chenopodiaceae* 61, and *Crassulaceae* 60.

The following families of European plants are not known to be represented by wild species in the flora of the Balkan Peninsula: *Palmae*, *Eriocaulonaceae*, *Myricaceae*, *Nyctaginaceae*, *Cneoraceae*, and *Diapensiaceae*.

The twenty largest genera, with the species each contains, are: *Centaurea* 171, *Silene* 103, *Dianthus* 101, *Trifolium* 94, *Campanula* 93, *Carex* 87, *Verbascum* 81, *Thymus* 78, *Ranunculus* 76, *Euphorbia* 73, *Astragalus* 70, *Galium* 70, *Viola* 58, *Allium* 60, *Senecio* 58, *Crepis* 56, *Vicia* 52, *Hypericum* 52, *Stachys* 52, *Veronica* 52.

As based on the number of species the *Gymnospermae* constitute 0·4 per cent., the *Monocotyledoneae* 15·9 per cent., and the *Dicotyledoneae* 83·7 per cent. of the whole flora.

In the sequence of families I have followed the system of Engler and Prantl. The general standard of genera is that of Thonner's *Exkursionsflora von Europa* (1901) and the *Nachträge* (1918), but for a few genera I have modified his conceptions on the lines of more recent researches. In nomenclature I have attempted to apply the generally accepted international rules, but in the relatively few ambiguities

which arose from their strict literal interpretation I have considered clarity of definition of more importance than priority under the rules.

EXPLANATION OF THE SYMBOLS USED.

The symbols used in this work are partly explained elsewhere, but for easy reference a complete key is given here.

A. *Genera and the number of species.*

B. *Duration.* ħ tree, ħ shrub, ɥ perennial herb, ② biennial herb, ① annual herb.

C. *Life-form* (*Raunkiaer's scheme*). MM = mega- or mesophanerophyte, M = microphanerophyte, N = nanophanerophyte, Ch = chamaephyte, H = hemicryptophyte, G = geophyte, HH = helophyte or hydrophyte, Th = therophyte.

D. *Life-form* (*extended scheme*). 1. Evergreen tree. 2. Deciduous tree. 3. Evergreen shrub. 4. Deciduous shrub. 5. Woody liane or sprawler. 6. Switch plant, leafless, or nearly leafless. 7. Plant with spines, thorns, or strong prickles. 9. Perennial herb, or sub-shrub, partially woody at the base, and the aerial parts dying back but not to ground level. 10. Grasses and grass-like plants. 11. Rush and sedge forms with suppressed leaves. 12. Perennial herbs and sub-shrubs with runners, or sprawling or ascending herbaceous or suffruticose stems. 13. Cushion plants. 14. Rosette plants. 15. Herbaceous twining plants, generally dying down each year. 16. Perennial herbs dying down yearly, with perennial buds on more or less thick stock at ground level. 17. Geophytes. 18. Annual herbs. 19. Hydrophytes. 20. Parasites and saprophytes.

E. *Habitats.* 1. Sea. 2. Freshwater. 3. Marshes, and at sides of ditches, streams, rivers, lakes, and ponds, and near springs. 4. Bogs. 5. Woods and forests, as trees, undergrowth, or ground-flora. 6. Brushwood. 7. Grassy places, meadows, and pastures. 8. Sandy places. 9. Stony and dry places, especially dry hill-slopes. 10. Stony and rocky humid places. 11. Dry rocks and walls and their crevices. 12. Melting snow. 13. Arable fields and gardens. 14. Vineyards. 15. Olive woods. 16. Ruderal places.

F. *Altitudinal zones.* 1. Coastal belt of maritime formations of dunes, salt-marshes, &c. 2. Lowland zone. 3. Hill zone. 4. Montane zone. 5. High mountain zone, 5a. lower division, 5b. middle division, 5c. upper division.

G. *Flowering period.* 1. January, 2. February, &c.

H. *Distribution within the Balkan Peninsula.* 1. Crete. 2. Greece. 2a. Cyclades. 3. Thessaly. 4. Epirus. 4a. Corfu. 5. Albania. 6. North Macedonia. 6a. South Macedonia. 6b. Athos Peninsula. 7. Thrace. 7a. Thracian islands. 8. North Bulgaria. 8a. South

Bulgaria. 8b. Rodope massif. 9. Dobruja. 10. Serbia. 10a. Novi Pazar. 11. Montenegro. 12. Bosnia. 13. Hercegovina. 14. Dalmatia. 15. South Croatia. 16. Istria.

I. *General distribution.* I. Cosmopolitan. I.a. Old World. II. North Temperate. III. East North Temperate. IV. General European. V. Mediterranean Regional. VI. Mediterranean Basin. VII. West Mediterranean Basin. VIII. South European. IX. Italian. X. East Mediterranean Basin. XI. Oriental. XII. Central European. XIII. Dacian. XIV. Pannonian. XIV.a. Pontic. XV. Alpine. XVI. West North African. XVII. Egyptian. XVIII. Caucasian. XIX. Balkan Peninsular. XX. Endemic.

The tabulation of the distributions of species is a difficult matter in which only partial success has been obtained. Every species has a distribution different from that of every other species, and a theoretically ideal classification has no practical value, but one built up on experience has been found to work fairly satisfactorily with some exceptions, which are always stated. The definitions of the symbols, figures, and terms used for the distribution within the Balkan Peninsula and for the general distribution of each species are given above, and for some in greater detail in a later chapter. In order to summarize the facts obtained by their use a further condensation has been made on the following basis:

Balkan Peninsular distribution:

Very wide: occurring in all districts mentioned under *H* above, or in all except the minor ones and one major one.

Wide: occurring in all but 2, 3, or 4 of the major districts.

Limited: occurring in 4 or more districts but absent from 5 or more major ones.

Very limited: occurring in only 1, 2, or 3 districts.

A few special distributions have to be dealt with separately. The phrase 'minor districts' is used in the special sense to mean 2a, 4a, 6b, 7a, and 10a, the remaining are 'major districts'.

General distribution.

Very wide: when referred to I., II., or III., as mentioned under I above.

Wide: when referred to IV., V., VI., or to combinations (with a few exceptions).

Limited: when referred to VII., VIII., IX., X., XI., XII., XIII., XIV., XIV.a., XV., XVI., and to a few combinations.

Very limited: when referred to XVII., XVIII., XIX., XX.

PHANEROGAMAE.

Families: 126.

A. Genera: 958. Species: 6530.
B. ħ/114 ħ/443 ɥ/4181 ②/481 ①/1486.
C. MM/80 M/172 N/258 Ch/1063 H/3105 G/636 HH/195 Th/1486.
D. 1/24 2/90 3/84 4/215 5/67 6/9 7/272 9/694 10/499 11/39 12/521 13/18 14/234 15/12 16/2553 17/571 18/1486 19/70 20/169.
E. 1/5 2/71 3/486 4/29 5/844 6/1051 7/1691 8/496 9/2127 10/82 11/1140 12/18 13/597 14/134 15/60 16/319.
F. 1/379 2/2661 3/3856 4/2803 5a/1306 5b/1193 5c/529.
G. 1/59 2/175 3/697 4/1666 5/2902 6/3481 7/3401 8/1961 9/652 10/213 11/98 12/49.
H. 1/1432 2/2973 2a/1106 3/1972 4/1074 4a/918 5/2059 6/2116 6a/2135 6b/723 7/2148 7a/142 8/2500 8a/1733 8b/1847 9/1298 10/2470 10a/228 11/2362 12/2022 13/1940 14/2292 15/2160 16/1970.
I. I./142 I.a/37 II./180 III./759 IV./221 V./495 VI./700 VII./40 VIII./338 IX./120 X./393 XI./291 XII./920 XIII./178 XIV./237 XIV.a/217 XV./283 XVI./9 XVII./8 XVIII./1061 XIX./273 XX./1754.

Gymnospermae.

Families: 3.

A. Genera: 7. Species: 25. **B.** ħ/16 ħ/11. **C.** MM/12 M/11 N/6. **D.** 1/16 3/11 6/3. **E.** 5/15 6/9 8/1 9/1 11/3. **F.** 2/8 3/6 4/6 5a/13 5b/3. **G.** 1/4 2/6 3/8 4/15 5/17 6/5 11/3 12/3. **H.** 1/7 2/14 2a/5 3/9 4/6 4a/5 5/16 6/15 6a/10 6b/9 7/10 7a/1 8/11 8a/2 8b/13 9/1 10/12 10a/5 11/15 12/9 13/15 14/15 15/10 16/9. **I.** II./2 III./1 IV./1 V./2 VI./4 VII./1 VIII./1 IX./1 X./4 XI./2 XII./5 XV./1 XVIII./12 XX./3.

Taxaceae. 1 species.

A. *Taxus* 1. **B.** ħ/1. **C.** MM/1 M/1. **D.** 1/1. **E.** 5/1. **F.** 5a/1. **G.** 4/1 5/1. **H.** 2/1 3/1 5/1 6/1 6a/1 6b/1 8/1 8a/1 8b/1 10/1 11/1 12/1 13/1 15/1 16/1. **I.** IV./1 XI./1 XVIII./1. In Bulgaria the yew usually occurs only in wet, swampy woods. In Greece it reaches as far south as Mt. Malevo in Laconia. It is relatively rare in Bulgaria and only just gets north of the boundary between North and South Macedonia to the north-east of Lake Doiran and between Demirkapu and Bitolia.

Pinaceae. 21 species.

A. *Pinus* 8, *Juniperus* 8, *Abies* 2, *Picea* 2, *Cupressus* 1. **B.** ħ/15 ħ/8. **C.** MM/11 M/10 N/3. **D.** 1/15 3/8. **E.** 5/14 6/8. All of the species form, partly or entirely, woods or brushwood, 4 occurring in the macchie.

F. 2/6 3/5 4/6 5a/11 5b/3. Two fairly well-marked conifer zones occur (excluding the junipers): the coastal and the high mountain zone. The latter is usually above the zone of summer deciduous woods, excepting at times that of *Fagus*. The genus *Juniperus* ranges, in different species and varieties, from the coastal macchie (*J. macrocarpa* and *J. oxycedrus*) to the second high mountain zone (*J. communis* vars.). **G.** 1/4 2/4 3/6 4/11 5/13 6/3 11/3 12/3. **H.** 1/6 2/11 2a/4 3/7 4/5 4a/4 5/13 6/12 6a/7 6b/7 7/8 7a/1 8/9 8a/1 8b/12 10/11 10a/5 11/12 12/7 13/12 14/12 15/8 16/7. Again the two zonal types are obvious. In Greece (2), Albania (5), Montenegro (11), Hercegovina (13), and Dalmatia (14) Mediterranean coastal and high mountain species both occur, giving the relatively high numbers. In the Rodopes (8b) it is especially the abundance of high mountain species which gives the total. In the Dobruja, where the Mediterranean climate and high mountains are both absent, there are no conifers. The occurrence of seven species on the Athos Peninsula (6b) is noteworthy. **I.** II./2 V./1 VI./4 VII./1 VIII./1 IX./1 X./3 XI./1 XII./5 XV./1 XVIII./10 XX./3.

The above distribution figures suggest that the conifers within the Balkan Peninsula have had different specific histories. The Mediterranean (mostly coastal) types (V. to XI.) predominate and are mainly represented by species of *Juniperus* and *Pinus*. The Central European (XII.) species are, in the Balkan Peninsula, mainly high mountain, and some might be considered Alpine (XV.) from our standpoint, for the districts in which they occur are linked to their main distributional areas by high mountains. No species is entirely Caucasian in its distribution outside the Balkan Peninsula. Of the three endemics (XX.), *Abies cephalonica* Loud. is morphologically not remarkably distinct from *A. alba* Mill. which has a wider distribution but also occurs in the Balkan Peninsula. *Pinus peuce* Griseb. is a very distinct species of pine related to *P. excelsa* Wall. from the Western Himalayas, and *Picea omorika* Willk. is also morphologically isolated from the only other species of spruce occurring in the Balkan Peninsula. All the evidence points to these being Tertiary relicts. It should be noted that several junipers regarded by some authors as species are here considered as varieties or forms of *Juniperus communis* (e.g. *nana* and *hemisphaerica*).

Gnetaceae. 3 species.

A. *Ephedra*, 3. **B.** ħ/3. **C.** N/3. **D.** 3/3 6/3. **E.** 6/1 8/1 9/1 11/3. **F.** 2/2 3/1 5a/1. **G.** 2/2 3/2 4/3 5/3 6/2. **H.** 1/1 2/2 2a/1 3/1 4/1 4a/1 5/2 6/2 6a/2 6b/1 7/2 8/1 9/1 11/2 12/1 13/2 14/3 15/1 16/1. **I.** III./1 V./1 X./1 XVIII./1. The distribution of the species of *Ephedra* within the Balkan Peninsula needs some detailed explanation. *E. distachya* L.

occurs near the coast on the eastern (Adriatic) and western (Black Sea) sides, but not in the southern except in Thrace. *E. campylopoda* C. A. Mey., whose distribution is X., is considered by Stapf a variety of *E. fragilis*. Both Stapf and Hayek retain *E. nebrodensis* Tineo (*E. major* Host) as one species, but there are apparently two geographically distinct varieties which might be considered as morphologically small species. The var. *villarsii* Stapf is found in the western parts of Hercegovina, Dalmatia, and Istria, and its general distribution is VII. The var. *procera* Stapf occurs in Greece, South Macedonia, up the Vardar Valley just into North Macedonia, and Thrace, and its general distribution is XI.

Monocotyledoneae.

Families: 18.

A. Genera: 210. Species: 1040. **B.** ħ/2 ɥ/880 ②/13 ①/161. **C.** M/2(?) N/3 Ch/3 H/348 G/472 HH/109 Th/161. **D.** 3/3 5/2 7/6 10/498 11/39 15/2 16/56 17/407 18/161 19/34 20/2. **E.** 1/5 2/35 3/172 4/20 5/132 6/144 7/320 8/130 9/331 10/17 11/74 12/5 13/62 14/11 15/11 16/22. **F.** 1/83 2/538 3/635 4/472 5a/204 5b/164 5c/57. **G.** 1/15 2/49 3/139 4/316 5/522 6/604 7/491 8/292 9/138 10/81 11/38 12/19. **H.** 1/281 2/513 2a/219 3/321 4/161 4a/237 5/292 6/297 6a/351 6b/94 7/395 7a/11 8/449 8a/348 8b/262 9/213 10/465 10a/20 11/420 12/373 13/352 14/438 15/421 16/422. **I.** I./68 I.a/20 II./81 III./143 IV./33 V./134 VI./122 VII./16 VIII./42 IX./15 X./24 XI./44 XII./126 XIII./21 XIV./27 XIV.a/36 XV./62 XVI./3 XVII./2 XVIII./189 XIX./42 XX./163.

Typhaceae. 6 species.

A. *Typha* 6. **B.** ɥ/6. **C.** HH/6. **D.** 16/6. **E.** 3/6. **F.** 2/6. **G.** 5/1 6/2 7/5 8/4. **H.** 1/1 2/1 2a/1 3/3 4/2 4a/1 5/3 6/2 6a/3 7/3 8/2 8a/3 8b/1 9/4 10/4 11/2 12/3 13/1 14/3 15/3 16/2. **I.** I./1 II./1 III./3 XII./1. The species are, like the majority of the aquatic and marsh plants in our flora, of wide general distribution. Within the Balkan Peninsula they are most numerous in the northern districts, Serbia and the Dobruja, only *Typha angustata* Bory et Chaub. extending to Crete, Greece, and the Cyclades.

Sparganiaceae. 5 species.

A. *Sparganium* 5. **B.** ɥ/5. **C.** HH/5. **D.** 16/5. **E.** 3/5. **F.** 2/2 3/3 4/2 5c/1. **G.** 6/5 7/5 8/4. **H.** 2/2 3/1 4/1 5/1 6/1 6a/1 7/1 8/2 8a/1 8b/3 9/1 10/3 11/2 12/3 13/2 14/2 15/3 16/1. **I.** II./2 III./1 IV./1 V./1 XII./1 XVIII./1. The species are of wide or rather wide general distribution, but *Sparganium erectum* L. (*S. ramosum* Huds.) is the only one occur-

ring in most of the Balkan Peninsular districts. *S. affine* Schnizl. is known from only 1 district, the Rodope massif.

Potamogetonaceae. 27 species.

A. *Potamogeton* 20, *Zostera* 2, *Althenia* 1, *Cymodocea* 1, *Posidonia* 1, *Ruppia* 1, *Zannichellia* 1. **B.** 4/27. **C.** HH/27. **D.** 19/27. **E.** 1/5 2/23. **F.** 1/5 2/16 2a/4 3/17 4/12 5a/12 5b/14. The species are fairly evenly distributed in altitude. **G.** 4/2 5/7 6/26 7/25 8/23 9/7. **H.** 1/7 2/13 2a/4 3/11 4/5 4a/8 5/7 6/7 6a/10 6b/1 7/12 7a/1 8/13 8a/8 9/10 10/14 11/17 12/11 13/10 14/14 15/16 16/17. On the whole there is an increase of the species to the north. Istria and Montenegro with 17, South Croatia with 16, and Dalmatia and Serbia each with 14 species, having the largest numbers. Three species occur in 1 district only. **I.** I./14 II./6 III./1 IV./2 V./1 VI./3 XII./1 XVIII./1. The majority of the species are widely spread. *Potamogeton acutifolius* Link is essentially, and is here counted as, Central European (XII.), but it is also recorded from Australia. *Zostera nana* Roth is essentially European and Mediterranean Regional (IV. and V.), and is so counted here, but it is also recorded from South Africa. *Cymodocea nodosa* Aschers. and *Posidonia oceanica* Delile are marine Phanerogams limited to the Mediterranean Basin. These two species are the most restricted in their general distribution of all the species of this family occurring in the Balkan Peninsula.

Naiadaceae. 2 species.

A. *Naias* 2. **B.** ①/2. **C.** HH/2 Th/2. **D.** 18/2 19/2. **E.** 2/2. **F.** 1/2 2/2. **G.** 6/1 7/1 8/2 9/2. **H.** 2/1 3/1 5/2 7/1 8/2 8a/1 9/1 10/2 11/2 12/1 13/1 14/1 15/1 16/2. **I.** I./1 I.a/1. The 2 species are of wide but apparently sporadic occurrence in the Balkan Peninsula, though until more detailed collecting has been done it is not possible to judge of their real frequency. Both are very wide in their general distribution.

Scheuchzeriaceae. 4 species.

A. *Triglochin* 4. **B.** 4/4. **C.** H/2 G/2. **D.** 16/2 17/2. **E.** 3/3 8/1 10/1. **F.** 1/3 2/2 3/1 4/1. **G.** 4/2 5/2 6/3 7/2 8/1 9/2 10/1 11/1. **H.** 1/1 2/2 4a/1 8/1 8a/1 9/1 10/1 11/1 12/1 13/1 14/2 15/2 16/2. **I.** I./2 V./2. *Triglochin bulbosa* L., essentially, and here counted as, Mediterranean Regional (V.), also occurs in South Africa. *T. laxiflora* Guss., a Mediterranean Regional species, is known only from northern Greece.

Alismataceae. 6 species.

A. *Alisma* 1, *Caldesia* 1, *Damasonium* 1, *Echinodorus* 1, *Elisma* 1, *Sagittaria* 1. **B.** 4/6. **C.** HH/6. **D.** 16/5 17/1. **E.** 3/6. **F.** 2/6 3/4. **G.** 4/1 5/2 6/3 7/5 8/5 9/3 10/11. **H.** 1/1 2/3 3/1 4/3 4a/1 5/1 6/1 6a/2

7/2 8/4 8a/1 8b/1 9/2 10/3 11/2 12/3 13/2 14/3 15/4 16/3. **I.** I./1 I.a/1 III./1 VI./2 XII./1. The species mostly have a wide general distribution, but *Damasonium bourgei* Coss. (Greece and Epirus) is limited to the Mediterranean Basin and *Echinodorus ranunculoides* Engelm. extends from the Mediterranean Basin to western Europe. Within the Balkan Peninsula *Alisma plantago* L. occurs in all the major divisions, but all the Balkan Peninsular specimens I have seen have the narrow leaves of the var. *lanceolatum* Wither. *Sagittaria sagittifolia* L. does not occur south of Epirus, South Macedonia, and Thrace. *Elisma natans* Buch. is recorded only from near Sevlievo in North Bulgaria.

Butomaceae. 1 species.

A. *Butomus* 1. **B.** 4/1. **C.** HH/1. **D.** 16/1. **E.** 3/1. **F.** 2/1 3/1. **G.** 5/1 6/1 7/1 8/1. **H.** 2/1 3/1 4/1 4a/1 5/1 6/1 6a/1 7/1 8/1 8a/1 8b/1 9/1 10/1 11/1 12/1 13/1 14/1 15/1 16/1. **I.** III./1. It is interesting to note that *Butomus umbellatus* L. occurs in all the major divisions of the Balkan Peninsula except Crete.

Hydrocharitaceae. 3 species.

A. *Hydrocharis* 1, *Stratiotes* 1, *Vallisneria* 1. **B.** 4/3. **C.** HH/3. **D.** 16/3. **E.** 2/3 3/1. **F.** 2/3 3/1. **G.** 5/1 6/2 7/2 8/2 9/1 10/1. **H.** 2/2 4/1 6/2 6a/1 7/1 8/2 8a/1 9/3 10/2 12/1 13/1 14/1 15/1. **I.** I./1 III./1 XII./1. The species appear to have a markedly discontinuous distribution in the Balkan Peninsula, but this may be due to insufficient collecting. In addition to the 3 species counted above *Elodea canadensis* L. has been recorded from the Dobruja by Pax, but I have seen no specimen from there and have no confirmation of the record. It is also present in Bulgaria, but I have no details of its occurrence in the Balkan Peninsula as a whole.

Gramineae. 358 species.

A. *Bromus* 35, *Poa* 25, *Festuca* 16, *Sesleria* 15, *Koeleria* 12, *Alopecurus* 10, *Avenastrum* 10, *Phleum* 10, *Lolium* 9, *Aegilops* 8, *Melica* 8, *Phalaris* 8, *Stipa* 8, *Trisetum* 8, *Agropyron* 7, *Agrostis* 7, *Vulpia* 7, *Brachypodium* 6, *Calamagrostis* 6, *Atropis* 5, *Elymus* 5, *Glyceria* 5, *Hordeum* 5, *Aira* 4, *Avena* 4, *Briza* 4, *Oryzopsis* 4, *Setaria* 4, *Anthoxanthum* 3, *Cynosurus* 3, *Deschampsia* 3, *Eragrostis* 3, *Holcus* 3, *Pholiurus* 3, *Polypogon* 3, *Andropogon* 2, *Apera* 2, *Arrhenatherum* 2, *Arundo* 2, *Catapodium* 2, *Dactylis* 2, *Digitaria* 2, *Erianthus* 2, *Gastridium* 2, *Haynaldia* 2, *Heleochloa* 2, *Hierochloe* 2, *Milium* 2, *Panicum* 2, *Schismus* 2, *Scleropoa* 2, *Secale* 2, *Ventenata* 2, *Aeluropus* 1, *Ammophila* 1, *Ampelodesmos* 1, *Antinoria* 1, *Avellinia* 1, *Beckmannia* 1, *Brachiaria* 1, *Catabrosa* 1, *Chaeturus* 1, *Chrysopogon* 1, *Crypsis* 1, *Cutandia* 1, *Cynodon* 1, *Danthonia* 1, *Diplachne* 1, *Echinaria* 1, *Echinochloa* 1, *Gaudinia* 1, *Hemarthria* 1, *Hetero-*

pogon 1, *Homalocenchrus* 1, *Hyparrhenia* 1, *Imperata* 1, *Lagurus* 1, *Lamarckia* 1, *Lepturus* 1, *Lygeum* 1, *Maillea* 1, *Mibora* 1, *Molinia* 1, *Nardus* 1, *Oplismenus* 1, *Periballia* 1, *Phacelurus* 1, *Phragmites* 1, *Psilurus* 1, *Sclerochloa* 1, *Sieglingia* 1, *Sorghum* 1, *Spartina* 1, *Sphenopus* 1, *Sporobolus* 1, *Tragus* 1, *Triplachne* 1, *Triticum* 1, *Weingaertneria* 1. **B.** 4/221 ②/13 ①/140. No species is known to behave always and entirely as a biennial. All the species, with 13 occasional exceptions, are annual or perennial herbs. **C.** Ch/3 H/196 G/34 HH/14 Th/140. The vast majority of the species are hemicryptophytes or therophytes. **D.** 10/358 18/140. **E.** 2/1 3/31 4/3 5/37 6/26 7/112 8/81 9/113 10/5 11/42 13/36 14/2 15/2 16/22. A majority of species occur in meadows and other characteristically 'grassy' places, and in dry situations, especially on dry hill-slopes. **F.** 1/45 2/205 3/189 4/152 5a/66 5b/62 5c/27. The greatest number of species occur in the lowlands and the next in the hill zone. The altitudinal limits of 6 species are unknown. **G.** 1/1 2/2 3/17 4/99 5/209 6/265 7/220 8/113 9/48 10/19 11/4 12/2. The maximum number of species flowering is reached in June, and the number gradually decreases from this month to the end of the year. The flowering periods of 10 species are unknown. **H.** 1/119 2/195 2a/104 3/145 4/83 4a/125 5/130 6/111 6a/148 6b/39 7/158 7a/5 8/167 8a/134 8b/107 9/75 10/169 10a/11 11/165 12/139 13/138 14/176 15/169 16/162. Greece (2) has most species, 195, Dalmatia (14) comes next with 176, Serbia (10) and Croatia (15) next with 169 each, North Bulgaria next with 167, and Istria (16) next with 162. Many more species than have been recorded hitherto must occur in Novi Pazar (10a), the Thracian Islands (7a), the Athos Peninsula (6b), and Epirus (4). **I.** I./25 I.a/4 II./34 III./45 IV./12 V./66 VI./32 VII./10 VIII./15 IX./6 X./12 XI./9 XII./36 XIII./11 XIV./10 XIV.a/11 XV./22 XVI./3 XVII./2 XVIII./78 XIX./19 XX./33. The highest individual number is 78 for species common to the Balkan Peninsula and the Caucasus. This number is misleading without explanation. It represents the total species common to the two areas excluding only those with a very wide distribution, and is due in the main to the meeting of Mediterranean, Central European, Dacian, and Pontic elements in both areas. Actually no species is designated solely XVIII., in other words, no species is a limited Caucasian one which has spread to the Balkan Peninsula. *Sesleria dorfleri* Hayek is morphologically related to a Caucasian species and is endemic to Crete. The next highest number is 66 for the Mediterranean Regional types (V.). Since the distributions V., VI., VII., VIII., IX., X., and XI. are all mutually exclusive, i.e. only one will be necessary for any one species, it is correct to summate the species under them to gain the Mediterranean element, thus obtaining the figure 150 or 41 per cent.

of the total 358 species. Again the figures I. to IV. inclusive are mutually exclusive, i. e. do not occur together, and all represent widely-distributed species totalling 120, or 33 per cent. of the total 358 species. The Central European types (XII.) and the Alpine (XV.) are remarkably small, mainly because many of the species common to the Balkan Peninsula and these areas have also a wider distribution and therefore come under another category. The endemics number 33 or 9·2 per cent. of the total 358 species.

The distribution of the following species and subspecies is worthy of special mention: *Ammophila arenaria* Link has a wide distribution round the coasts, being recorded from Crete, Greece, the Cyclades, Corfu, Thrace, eastern Bulgaria, Dobruja, Montenegro, and Dalmatia. All the specimens from these districts which I have seen belong to the var. *arundinacea* Husnot *Gramin.* 19 (Cahan, 1896), which might better be regarded as a subspecies. The species is distributed from the Faeroes to the eastern Baltic, on the Atlantic coasts of Europe and North America, in the Mediterranean Basin from Spain and Morocco to Palestine and Egypt, and occurs again on the western shores of the Black Sea. All the plants I have seen from the Mediterranean and Black Sea countries, except a few from the west, are the var. *arundinacea*, though all the characters of this are not well shown in every example. *Elymus delileanus* Schult. is an Oriental and east North African species also known from eastern Crete (Cape Sidero). *Festuca porcii* Hackel is a Carpathian species which is also recorded from Montenegro. *Haynaldia hordeacea* Hackel is a west North African species occurring in Greece (Laconia). *Maillea crypsoides* Boiss. occurs in Greece (Attica), the Cyclades, and Sardinia. *Poa bivonae* Parl. occurs in Thessaly (Pindus) and Sicily. *Poa laxa* Haenke, occurring in North Bulgaria and the Rodopes, has a very discontinuous distribution on the mountains of Central Europe. *Poa nemoralis* L. subsp. *balbisii* Hackel (*P. capitata* Aschers. et Graebn.) is recorded from Corfu and from the high mountains of Corsica and Sardinia. *Triplachne nitens* Link has a very discontinuous distribution in the Mediterranean Basin and is recorded from Crete, and the same is true of *Vulpia setacea* Parl. Several species are largely represented in our flora by what are at present considered varieties different from varieties met with in northern and western Europe. Many of the specimens of *Bromus hordeaceus* L. I have seen from the Balkan Peninsula belong to the var. *molliformis* Hal. *Consp. Fl. Gr.* iii. 396 (1904), which is not equivalent to the *B. molliformis* Lloyd. *Dactylis glomerata* L. is mainly represented by plants, generally named var. *hispanica* Roth, with compact inflorescences.

Cyperaceae. 140 species.

A. *Carex* 87, *Scirpus* 18, *Cyperus* 9, *Heleocharis* 7, *Eriophorum* 5, *Juncellus* 4, *Fimbristylis* 2, *Pycreus* 2, *Schoenus* 2, *Cladium* 1, *Cobresia* 1, *Mariscus* 1, *Rhynchospora* 1. **B.** 4/127 ①/13. **C.** H/96 G/18 HH/35 Th/13. **D.** 10/122 11/19 18/13. **E.** 3/75 4/12 5/23 6/17 7/39 8/16 9/15 10/5 11/4 13/1 14/1. The commonest habitats are marshy or semi-marshy places (3) then grassy places (7), and then woods (5). In general the distribution is in habitats little disturbed by man and his flocks. **F.** 1/8 2/69 3/81 4/77 5a/37 5b/27 5c/8. A majority of the species are found in the hill and montane altitudinal zones. **G.** 2/1 3/8 4/35 5/82 6/97 7/78 8/48 9/27 10/9 11/3 12/1. The number of species flowering each month gradually increases to a maximum in June and then as gradually decreases to December. **H.** 1/25 2/49 2a/14 3/45 4/12 4a/27 5/31 6/46 6a/32 6b/11 7/48 8/74 8a/48 8b/28 9/29 10/83 10a/2 11/69 12/58 13/45 14/50 15/67 16/58. The largest numbers of species are found in Serbia with 83, North Bulgaria with 74, Montenegro with 69, Croatia with 67, and Bosnia and Istria with 58 each. The family is thus much better represented in the northern and central parts than in the southern and Mediterranean parts. This is especially true for the largest genus, *Carex*. Seventeen species of the family are known from only one area in the Balkan Peninsula. Many of the specimens of *Carex flacca* Schreb. belong to the var. *cuspidata* Aschers. et Graebn. **I.** I./13 I.a/12 II./24 III./37 IV./7 V./16 VI/5 VII./3 VIII./2 IX./1 X./2 XI./1 XII./27 XIII./1 XIV./3 XIV.a/5 XV./17 XVIII./18 XX./2. The majority of species are widely spread, with the East North Temperate (III.) most numerous. From I. to III. inclusive and XII. the species number 113 or 80·7 per cent. There are no species with the centre of distribution in the Balkan Peninsula (XIX.) and only two endemics (XX.), both doubtful species. Some of the species here listed as III. are, for the Balkan Peninsula, essentially XII., and some of those listed as XII. are essentially XV.

Araceae. 12 species.

A. *Arum* 5, *Biarum* 3, *Acorus* 1, *Arisarum* 1, *Calla* 1, *Dracunculus* 1. **B.** 4/12. **C.** H/1 G/10 HH/2. **D.** 16/3 17/10. **E.** 2/1 3/2 6/4 7/1 9/7 15/2. **F.** 2/10 3/10 4/7 5a/3 5b/1. Most species are found in the lowlands and in the hill zone, **G.** 1/2 2/2 3/3 4/7 5/9 6/4 7/1 10/2 11/2 12/2. Most species are flowering in May, but two are winter flowering. The flowering period of *Biarum fraasianum* Nym. is unknown. **H.** 1/5 2/8 2a/5 3/4 4/2 4a/4 5/1 6/1 6a/3 6b/1 7/4 7a/1 8/2 8a/3 9/1 10/3 11/3 12/3 13/3 14/6 15/5 16/4. The greatest number of species occurs in Greece, and on the whole more are found in the Mediterranean areas than in the Central European. Four species occur each in one area

only in the Balkan Peninsula and 3 of these are endemic. **I.** II./2 IV./1 V./2 VI./2 X./1 XIV.a/1 XVIII./3 XX./4. The general distribution of the species is very varied for so small a family.

Lemnaceae. 5 species.

A. *Lemna* 3, *Spirodela* 1, *Wolffia* 1. **B.** 4/5. **C.** HH/5. **D.** 19/5. **E.** 2/5. **F.** 2/5 3/4. **G.** 5/4 6/4 7/3 8/3. The flowering period of *Wolffia arrhiza* Wimm. is unknown. **H.** 1/1 2/4 2a/1 3/1 4/1 4a/2 5/1 6/3 6a/3 7/4 8/3 8a/5 8b/1 9/5 10/4 11/1 12/3 14/4 15/2 16/4. **I.** I./4 I.a/1. All the species have an extensive distribution both within and without the Balkan Peninsula. The only species known to occur in Crete is *Lemna minor* L.

Juncaceae. 40 species.

A. *Juncus* 29, *Luzula* 11. **B.** 4/35 ⊙/5. **C.** H/23 G/12 HH/2 Th/5. **D.** 10/18 11/20 18/5. **E.** 3/25 4/4 5/8 7/11 8/4 9/3 11/1. A majority of species (including all of *Juncus*) occur in wet places. **F.** 1/6 2/19 3/19 4/17 5a/10 5b/9 5c/8. The altitudinal limits of *Juncus striatus* Schousb. are unknown. The family is widely distributed in altitude, with a majority of species in the lowlands and hill zone. **G.** 3/1 4/4 5/13 6/32 7/31 8/23 9/12 10/2. A majority of species flower in June and July. **H.** 1/10 2/17 2a/7 3/16 4/6 4a/5 5/5 6/18 6a/19 6b/4 7/16 8/23 8a/11 8b/17 9/7 10/23 11/21 12/19 13/14 14/16 15/21 16/20. The family is, allowing for the sizes of the areas, fairly uniformly distributed. Three species occur each in only one area. **I.** I./6 I.a/1 II./7 III./7 IV./1 V./5 VI./4 VIII./2 IX./1 X./1 XI./1 XII./7 XIII./1 XIV./1 XIV.a/1 XV./9 XVIII./4 XIX./1(?). Twenty-one, or just over 50 per cent. of the species are very widely distributed forms (I. to III.). There are no endemics in the Balkan Peninsula, and only one species, *Juncus thomasii* Ten. is, doubtfully, of Balkan Peninsular origin.

Liliaceae. 248 species.

A. *Allium* 60, *Ornithogalum* 27, *Colchicum* 23, *Muscari* 21, *Fritillaria* 19, *Tulipa* 18, *Gagea* 11, *Asparagus* 9, *Hyacinthus* 9, *Lilium* 6, *Scilla* 6, *Asphodelus* 5, *Polygonatum* 5, *Asphodeline* 3, *Merendera* 3, *Ruscus* 3, *Anthericum* 2, *Chionodoxa* 2, *Lloydia* 2, *Smilax* 2, *Veratrum* 2, *Bulbocodium* 1, *Convallaria* 1, *Erythronium* 1, *Maianthemum* 1, *Narthecium* 1, *Nectaroscordum* 1, *Paris* 1, *Streptopus* 1, *Tofieldia* 1, *Urginea* 1. **B.** ħ/2 4/245 ⊙/1. **C.** M/2(?) N/3 H/9 G/235 Th/1. **D.** 3/3 5/2 7/6 16/9 17/235 18/1. **E.** 3/2 4/1 5/32 6/57 7/67 8/18 9/107 10/3 11/20 12/2 13/25 14/6 15/6. The chief habitat of the species of this family is in dry stony places. **F.** 1/11 2/118 3/166 4/114 5a/44 5b/32 5c/10. The altitudinal limits of 9 species are unknown. A majority of species occur in the hill zone. **G.** 1/7 2/14 3/52 4/92 5/105 6/86 7/73

8/49 9/23 10/20 11/11 12/5. The flowering period of 15 species is unknown. The maximum flowering period is in May. **H.** 1/48 2/112 2a/51 3/57 4/28 4a/23 5/50 6/63 6a/62 6b/25 7/67 7a/3 8/91 8a/79 8b/55 9/44 10/75 10a/3 11/65 12/57 13/72 14/77 15/68 16/69. The largest number of species is found in Peninsular Greece (2), but it was unexpected that the next largest number would be found to occur in North Bulgaria (8). That Novi Pazar (10a) and the Thracian Islands (7a) have only 3 recorded species each is due to the lack of specimens and reliable records from these areas. Seventy-four species are recorded from 1 area only in the Balkan Peninsula. While most of these are endemics, it is a general characteristic of the family that a majority of the species, namely 160 out of 248 or 64·5 per cent., occur in only 6 or less of the areas adopted within the Balkan Peninsula. **I.** II./2 III./29 IV./6 V./20 VI./33 VIII./11 IX./5 X./6 XI./19 XII./16 XIII./7 XIV./7 XIV.a/13 XV./9 XVIII./47 XIX./7 XX./93. Ninety-three out of 248 species, or 37 per cent., are endemic, and most of these are well-marked species. The figure 47 for species, excluding widely distributed ones, common to the Balkan Peninsula and Caucasus is misleading. Actually only two species are common to the Balkan Peninsula and the Caucasus but not found in any other area. Ninety-four species are Mediterranean in a broad sense, excluding endemics and Balkan Peninsular types, 75 per cent. of the species are Mediterranean or endemic, while only 12·5 per cent. are widely distributed (I.–III.).

Amaryllidaceae. 23 species.

A. *Narcissus* 10, *Galanthus* 6, *Leucojum* 3, *Sternbergia* 3, *Pancratium* 1. **B.** 4/23. **C.** G/23. **D.** 17/23. **E.** 3/2 5/5 6/5 7/9 8/1 9/12 11/1 14/2. **F.** 1/1 2/6 3/18 4/8 5a/4 5b/2 5c/1. **G.** 1/2 2/7 3/11 4/12 5/3 9/6 10/6 11/4 12/5. **H.** 1/5 2/12 2a/5 3/3 4/2 4a/3 5/8 6/5 6a/6 6b/2 7/9 8/5 8a/6 8b/5 9/3 10/8 10a/1 11/6 12/5 13/5 14/13 15/5 16/6. Three species, 2 of them endemics, occur in only 1 district each. Species of the family are fairly well distributed over the districts with a maximum concentration in Dalmatia and Greece. **I.** V./2 VI./5 VII./1 VIII./5 XI./2 XII./4 XIV.a/2 XV./1 XVIII./4 XIX./1 XX./3. There are no very widely distributed species. Fifteen of the 23 species, or 65·2 per cent., excluding endemics, are Mediterranean in general distribution.

Dioscoreaceae. 2 species.

A. *Dioscorea* 1, *Tamus* 1. **B.** 4/2. **C.** G/2. **D.** 15/2 17/2. **E.** 5/2 6/1 9/1. **F.** 2/1 3/2 4/1. **G.** 3/1 4/1 5/2 6/2. **H.** 1/1 2/1 2a/1 3/1 4/1 4a/1 5/2 6/1 6a/1 7/1 8/1 8a/1 8b/1 10/1 11/1 12/1 13/1 14/1 15/1 16/1. **I.** V./1 XII./1 XVIII./1 XX./1. *Tamus communis* L. is recorded for all the major areas except the Dobrudja. The relict species *Dioscorea balcanica*

Košanin occurs only in Albania and has glabrous leaves. The distribution of its taxonomic relatives is of considerable interest. *D. caucasica* Lipsky of the Caucasus has hairy leaves, *D. deltoidea* Wall., from the north-western Himalayas and south-western China, also has hairy leaves, while *D. prazeri* Prain et Burkill ranges from Central Nepal to the eastern Himalayas, Burma, and lower Siam, and has glabrous leaves.

Iridaceae. 61 species.

A. *Crocus* 29, *Iris* 19, *Gladiolus* 7, *Romulea* 5, *Hermodactylus* 1. **B.** 4/61. **C.** H/17 G/43 HH/1. **D.** 16/18 17/43. **E.** 3/2 5/3 6/17 7/21 8/6 9/34 10/3 11/5 12/3. Stony dry places have 34 species, while brushwood is next with 17 species. The habitats of 6 species are unknown. **F.** 1/2 2/29 3/42 4/25 5a/5 5b/4 5c/1. The majority of species occur in the hill zone. **G.** 1/2 2/20 3/20 4/18 5/22 6/20 7/7 9/3 10/10 11/13 12/3. Spring (and early summer) and autumn maxima for species in flower are well marked. **H.** 1/18 2/27 2a/13 3/11 4/5 4a/11 5/15 6/11 6a/20 6b/3 7/23 8/17 8a/20 8b/11 9/8 10/22 10a/1 11/18 12/12 13/15 14/17 15/13 16/15. Most species occur in Peninsular Greece (2) and decreasing numbers in Thrace (7), Serbia (10), South Macedonia (6a), and South Bulgaria (8a). Nine species occur in only 1 district. **I.** III./1 V./8 VI./10 VIII./4 IX./2 XI./5 XII./7 XIII./1 XIV./6 XIV.a/3 XV./1 XVIII./10 XIX./11 XX./15. The endemics (15 species) and the Balkan Peninsular types (11 species) together account for 42 per cent. of the species. The Mediterranean element, excluding endemics and Balkan Peninsular types, amounts to 47·5 per cent. No species is solely Caucasian (XVIII.) outside the Balkan Peninsula.

Orchidaceae. 97 species.

A. *Orchis* 34, *Ophrys* 24, *Serapias* 6, *Cephalanthera* 4, *Epipactis* 4, *Gymnadenia* 4, *Aceras* 2, *Listera* 2, *Platanthera* 2, *Spiranthes* 2, *Anacamptis* 1, *Coeloglossum* 1, *Coralliorrhiza* 1, *Cypripedium* 1, *Epipogon* 1, *Goodyera* 1, *Herminium* 1, *Limodorum* 1, *Liparis* 1, *Loroglossum* 1, *Neotinea* 1, *Neottia* 1, *Nigritella* 1. **B.** 4/97. **C.** H/4 G/93. **D.** 16/4 17/91 20/2. The uniformity in general habit and life-form is striking. **E.** 3/11 5/22 6/17 7/60 8/3 9/39 11/1 15/1. The species mainly occur in natural grassy, stony, woody, or marshy habitats, undisturbed by man. The habitats of *Ophrys argolica* Fleischm. and *O. omegaifera* Fleischm. are unknown. **F.** 2/38 3/77 4/56 5a/23 5b/13 5c/1. A majority of species occur in the hill and montane zones. The altitudinal limits of *Ophrys argolica* Fleischm. and *Orchis serbica* Fleischm. are unknown. **G.** 1/1 2/3 3/26 4/43 5/59 6/51 7/32 8/14 9/4 12/1. The maximum flowering periods are May and June. The flowering period of *Ophrys argolica* Fleischm. is unknown to me. **H.** 1/39 2/63 2a/13

Verbascum.

Species of mullein are very characteristic of the dry hill-slopes of the Balkan Peninsula and they frequently hybridize with one another. The plant photographed was grown from seed collected above Rila, Bulgaria, and is probably a hybrid for which the ancestry *V. lychnitis* L. × *V. jankaeanum* Panč. is suggested.

Iris varbossania K. Maly.

This was described as a species from Bosnia. It probably arose from the crossing of *Iris variegata* L. and *I. pallida* Lam. The plant figured was derived from the type stock and makes a magnificent show at Kew in June.

3/20 4/8 4a/24 5/34 6/24 6a/39 6b/8 7/44 7a/1 8/39 8a/24 8b/31 9/18 10/47 10a/2 11/44 12/52 13/40 14/51 15/39 16/55. Peninsular Greece (2), Istria (16), Bosnia (12), and Dalmatia (14) are exceptionally rich in species. This agrees with the results obtained under **I**, since the Mediterranean species exceed in number the Central European ones. Fifteen are limited to one district, and of these 9 are endemic. **I.** II./3 III./16 IV./3 V./10 VI./26 VII./2 VIII./3 X./1 XI./7 XII./23 XV./3 XVIII./22 XIX./3 XX./13. The figures under this category, while indicating the two distributional types of Mediterranean and Central European for this family, do not by themselves yield exceptional results. Twenty of the 24 species of *Ophrys* and 14 of the 34 species of *Orchis* are essentially southern (Mediterranean). The relatively high figure, 22, for XVIII. is due to the meeting within the Caucasian area of both Mediterranean and Central European species. None of the recorded species is limited to the Caucasian area and the Balkan Peninsula. No cosmopolitan (I.), no purely Italian (IX.), Dacian (XIII.), Pannonian (XIV.), or Pontic (XIV.a) species are recorded. The 13 endemics all belong to the 3 largest genera: 8 to *Ophrys*, 3 to *Orchis*, and 2 to *Serapias*. There are no endemic genera. Of the species whose centre of distribution is in the Balkan Peninsula, the most interesting is *Gymnadenia frivaldii* Hampe, which also occurs in the Transylvanian Alps and (?) in the Banat.

Dicotyledoneae.

Families: 105.

A. Genera: 741. Species: 5465. **B.** ħ/98 ħ/430 ɯ/3301 ②/468 ①/1325. **C.** MM/68 M/159 N/249 Ch/1060 H/2757 G/164 HH/86 Th/1325. **D.** 1/8 2/90 3/70 4/215 5/65 6/6 7/266 9/694 12/521 13/18 14/234 15/10 16/2498 17/164 18/1325 19/36 20/167. **E.** 2/36 3/314 4/9 5/697 6/898 7/1371 8/365 9/1795 10/65 11/1063 12/13 13/535 14/123 15/49 16/297. **F.** 1/296 2/2115 3/3215 4/2325 5a/1089 5b/1026 5c/472. **G.** 1/40 2/120 3/550 4/1335 5/2363 6/2872 7/2910 8/1669 9/514 10/132 11/57 12/27. **H.** 1/1144 2/2446 2a/882 3/1642 4/907 4a/676 5/1751 6/1814 6a/1774 6b/620 7/1743 7a/130 8/2040 8a/1383 8b/1572 9/1084 10/1993 10a/203 11/1927 12/1640 13/1573 14/1839 15/1729 16/1539. **I.** I./74 I.a/17 II./97 III./615 IV./187 V./359 VI./574 VII./23 VIII./295 IX./104 X./365 XI./245 XII./789 XIII./157 XIV./210 XIV.a/181 XV./220 XVI./6 XVII./6 XVIII./860 XIX./231 XX./1588.

Salicaceae. 27 species.

A. *Salix* 24, *Populus* 3. **B.** ħ/5 ħ/22. **C.** MM/5 M/13 N/13. **D.** 2/5 4/22. **E.** 3/19 4/1 5/6 6/6 7/6 9/3. **F.** 2/8 3/13 4/16 5a/13 5b/12 5c/5. **G.** 2/1 3/13 4/18 5/11 6/8 7/6. Most species are flowering in April. The

flowering periods of *Salix herbacea* L. and *S. reticulata* L. are unknown. **H.** 1/4 2/12 2a/3 3/7 4/4 5/6 6/11 6a/10 6b/3 7/8 7a/1 8/17 8a/7 8b/12 9/7 10/15 10a/3 11/15 12/18 13/15 14/8 15/19 16/12. Croatia with 19 species has most, Bosnia with 18 coming next. The fact that few species are recorded from Epirus and Albania, and none from Corfu, probably indicates the reduction of the genus towards the south, since the 12 species from Greece are, with few exceptions, of very local occurrence. **I.** II./4 III./16 IV./1 VIII./2 XII./3 XV/9 XVIII./1. XIX./1. On the whole the species are northern in their distribution. Indeed many classified under III. are for the Balkan Peninsula really XII. or XV. *Salix amplexicaulis* Ch. et B. is classified as XIX.

Juglandaceae. 1 species.

A. *Juglans* 1. **B.** ħ/1. **C.** MM/1. **D.** 2/1. **E.** 5/1. **F.** 3/1 4/1. **G.** 4/1 5/1. **H.** 2/1 3/1 4/1 5/1 6/1 6a/1 7/1 8/1 8a/1 8b/1 9/1 10/1 10a/1 11/1 12/1 13/1 15/1. **I.** XI./1 XVIII./1. *Juglans regia* L. has a wide distribution within the Balkan Peninsula. It is, however, so often cultivated that it is sometimes difficult to know when it is really native and when only an escape from or relict of cultivation.

Betulaceae. 11 species.

A. *Alnus* 3, *Corylus* 3, *Betula* 2, *Carpinus* 2, *Ostrya* 1. **B.** ħ/10 ħ/6. **C.** MM/8 M/7 N/1. **D.** 2/10 4/6. **E.** 3/1 5/9 6/4 9/1 11/1. **F.** 2/1 3/8 4/8 5a/5 5b/2. **G.** 2/3 3/5 4/8 5/6 6/2 7/1 8/1. **H.** 2/6 2a/1 3/6 4/3 5/6 6/8 6a/5 6b/6 7/7 8/7 8a/4 8b/8 9/4 10/8 10a/5 11/8 12/9 13/7 14/4 15/9 16/8. On the whole there is a predominance in the Central European areas, and it is of interest to note that no species occurs in Crete. **I.** II./2 III./5 IV./1 XI./2 XII./1 XVIII./3 XIX./1. For the Balkan Peninsula several of the species classed as III. may be considered XII. *Corylus maxima* Mill. is classed as XIX.

Fagaceae. 19 species.

A. *Quercus* 16, *Fagus* 2, *Castanea* 1. **B.** ħ/19 ħ/8. **C.** MM/17 M/10 N/2. **D.** 1/2 2/17 3/2 4/6. **E.** 5/17 6/5 9/2 11/1. **F.** 2/6 3/16 4/11 5a/1. The hill zone is the zone where oaks are dominant though 9 reach into the montane zone. **G.** 4/9 5/16 6/4 7/1. Most species flower in June. **H.** 1/5 2/11 2a/5 3/12 4/10 4a/2 5/13 6/7 6a/10 6b/5 7/10 7a/1 8/5 8a/7 8b/7 9/6 10/8 10a/5 11/12 12/9 13/10 14/10 15/9 16/10. **I.** IV./2 V./1 VI./4 VIII./3 IX./2 X./1 XI./2 XII./2 XIV./2 XIV.a/3 XVIII./5 XIX./4. The importance of this family as forest dominants necessitates a special analysis. Essentially four groups may be recognized: 4 species are Central European, 9 species are Mediterranean, 1 species (*Fagus orientalis* Lipsky) is Pontic, being

distributed from the Caucasus to the Bithynian Olympus in Asia Minor, while 4 species (*Quercus conferta* Kit., Q *macedonica* Griseb., *Q. pedunculiflora* Koch, and *Q. pendulina* Kit.) are Balkan Peninsular types. *Quercus lanuginosa* Thuill. is both Central European and Mediterranean. It is probable that *Fagus silvatica* L. does not reach hills near the Black Sea.

Ulmaceae. 7 species.

A. *Celtis* 3, *Ulmus* 3 (?), *Zelkova* 1. **B.** ħ/6 ħ/2. **C.** MM/5 M/2 N/1. **D.** 2/6 4/2. **E.** 5/5 6/4 9/1. **F.** 2/3 3/6 4/4. **G.** 3/4 4/5 5/3. The flowering period of *Celtis caucasica* Willd. is unknown. **H.** 1/3 2/4 2a/2 3/3 5/4 6/2 6a/2 7/2 8/4 8a/4 8b/3 9/2 10/3 10a/1 11/3 12/3 13/4 14/2 15/4 16/2. **I.** III./2 V./1 X./1 XI./2 XII./2 XIII./1 XVIII./3. The species of *Ulmus* have been taken in a broader sense than may be advisable when more material is available. *Celtis australis* L. occurs in most of the major districts; *C. caucasica* Willd. is limited, within the Balkan Peninsula, to North and South Bulgaria; *C. tournefortii* Lam. occurs in Greece, the Cyclades, and Hercegovina. *Zelkova abelicea* Boiss. is endemic to Crete and Cyprus.

Moraceae. 2 species.

A. *Ficus* 1, *Humulus* 1. **B.** ħ/1 ħ/1 ɥ/1. **C.** M/1 H/1. **D.** 2/1 4/1 15/1. **E.** 6/1 9/1 11/1. **F.** 2/2 3/2 4/2. **G.** 7/2 8/1 9/1. **H.** 1/1 2/2 2a/1 3/2 4/1 4a/1 5/2 6/2 6a/2 6b/1 7/2 7a/1 8/2 8a/2 8b/2 9/2 10/1 11/2 12/2 13/2 14/2 15/2 16/2. **I.** III./1 V./1 XVIII./1. In addition to the above, the following are common in cultivation and often occur more or less spontaneously: *Broussonetia papyrifera* L'Hérit., *Cannabis sativa* L., *Morus alba* L., and *M. nigra* L. The fig is probably native to the Balkan Peninsula, but since it is so widely cultivated it often occurs as an escape from or relict of cultivation.

Urticaceae. 8 species.

A. *Parietaria* 4, *Urtica* 4. **B.** ɥ/5 ☉/3. **C.** H/5 Th/3. **D.** 16/5 18/3. **E.** 5/1 11/4 16/8. **F.** 2/8 3/6 4/3. **G.** 1/1 2/4 3/5 4/5 5/6 6/7 7/8 8/4 9/4 10/1 11/1 12/1. **H.** 1/7 2/8 2a/7 3/3 4/3 4a/4 5/6 6/4 6a/6 6b/1 7/7 7a/1 8/4 8a/3 8b/3 9/5 10/5 10a/1 11/7 12/3 13/5 14/6 15/3 16/5. **I.** I./1 III./1 V./2 VI./3 IX./1 XII./2 XVIII./3 XIX./1. *Parietaria cretica* L. occurs in Crete, Greece, the Cyclades, and Linosa and is thus almost endemic to our flora. All of the species occur as ruderals and most of them have a wide distribution within the Balkan Peninsula, and either a wide or a Mediterranean general distribution.

Loranthaceae. 3 species.

A. *Arceuthobium* 1, *Loranthus* 1, *Viscum* 1. **B.** ħ/3. **C.** N/3. **D.** 3/3 20/3. **E.** 5/2 6/1. **F.** 2/3 3/3 4/3. **G.** 3/1 4/2 5/1 6/1. **H.** 1/1 2/3 3/3

4/2 5/3 6/3 6a/3 6b/2 7/3 8/2 8b/2 9/2 10/3 11/1 12/3 13/3 14/3 15/3 16/3. **I.** III./1 V./1 VIII./1 XII./1 XVIII./1. The detailed distribution of the three species of this family has been given elsewhere (Turrill in *Kew Bull.* 1926, 376).

Santalaceae. 17 species.

A. *Thesium* 15, *Comandra* 1, *Osyris* 1. **B.** ħ/3 ɣ/13 ①/3. **C.** N/2 Ch/2 H/12 Th/3. **D.** 3/1 9/2 12/2 16/11 18/3 20/17. **E.** 5/3 6/4 7/5 8/1 9/8 11/2 13/3. **F.** 2/6 3/2 4/8 5a/3 5b/3 5c/1. **G.** 3/1 4/1 5/6 6/9 7/11 8/7. The flowering periods of *Thesium brachyphyllum* Boiss. and *T. bulgaricum* Vel. are unknown. **H.** 1/3 2/5 2a/3 3/4 4/2 4a/2 5/7 6/8 6a/4 6b/2 7/7 8/9 8a/6 8b/4 9/2 10/6 11/8 12/7 13/8 14/6 15/7 16/5. Two species (1 endemic) occur each in only 1 district, and 4 species (2 endemic) are limited to Bulgaria (8 and 8a). **I.** III./4 V./1 VI./2 IX./1 X./1 XI./1 XII./3 XIII./1 XIV./3 XVIII./1 XIX./2 XX./3. The general distribution of the species suggests a rather complex history for the family in our area. There have probably been several independent immigrations, mainly from the east, and a small local development of new species.

Aristolochiaceae. 12 species.

A. *Aristolochia* 11, *Asarum* 1. **B.** ɣ/12. **C.** H/2 G/10. **D.** 15/2 16/2 17/10. **E.** 5/3 6/8 7/1 8/1 9/3 11/2 13/2 14/1. **F.** 2/8 3/9 4/4. **G.** 3/3 4/10 5/11 6/5 7/3. **H.** 1/2 2/5 2a/3 3/2 4/1 4a/2 5/3 6/3 6a/5 6b/2 7/5 8/4 8a/1 8b/3 9/2 10/3 10a/1 11/4 12/4 13/4 14/4 15/4 16/4. **I.** III./1 IV./1 VI./4 XI./1 XVIII./1 XX./5. *Aristolochia clematitis* L. has the widest general distribution. This species occurs in most of the districts north of Greece and the Cyclades, whence, as from Crete and the Ionian islands, it is not recorded. The family as represented in our flora is essentially Mediterranean, and a relatively high degree of local development is indicated by the occurrence of 5 endemics.

Rafflesiaceae. 1 species.

A. *Cytinus* 1. **B.** ɣ/1. **C.** G/1. **D.** 17/1 20/1. **E.** 6/1. **F.** 2/1 3/1. **G.** 3/1 4/1 5/1 6/1. **H.** 1/1 2/1 2a/1 4a/1 7/1 14/1 16/1. **I.** VI./1. The one species, *Cytinus hypocistis* L., is Mediterranean both in its general and in its Balkan Peninsular distribution, and is found in macchie and phrygana parasitic on species of *Cistus*.

Polygonaceae. 50 species.

A. *Polygonum* 23, *Rumex* 23, *Atraphaxis* 1, *Emex* 1, *Oxyria* 1, *Rheum* 1. **B.** ħ/1 ɣ/31 ②/5 ①/20. **C.** N/1 Ch/6 H/25 G/6 HH/4 Th/20. **D.** 7/1 12/6 16/26 17/6 18/20 19/2. **E.** 2/1 3/12 5/7 6/5 7/14 8/9 9/7 11/6 13/11 15/1 16/10. **F.** 1/5 2/27 3/30 4/25 5a/11 5b/11 5c/5. **G.**

2/1 3/3 4/5 5/13 6/30 7/39 8/37 9/22 10/8 11/2 12/1. The maximum flowering period is in July and August, i.e. past midsummer. The flowering period of *Polygonum idaeum* Hayek is unknown. **H.** 1/15 2/27 2a/10 3/28 4/16 4a/11 5/25 6/22 6a/25 6b/10 7/23 8/28 8a/23 8b/16 9/19 10/29 10a/4 11/23 12/25 13/21 14/20 15/28 16/21. Four species (1 endemic) are limited to 1 district each. **I.** I./11 I.a/2 II./6 III./11 IV./1 V./3 VI./4 VIII./2 IX./1 X./1 XI./1 XII./4 XIV./1 XV./3 XVIII./4 XIX./2 XX./3. That 30 out of 50 species should be so widely distributed (I. to III. inclusive) is noteworthy, but is partly due to the number of weeds and ruderals. The most peculiar case of distribution within the family is that of *Rheum rhaponticum* L., which occurs in the Rodope and in Siberia! *Rumex nepalensis* Spreng. has also a strange discontinuous distribution which is detailed elsewhere (p. 227). The 3 endemics are morphologically not very well characterized species.

Chenopodiaceae. 61 species.

A. *Chenopodium* 14, *Atriplex* 10, *Suaeda* 5, *Beta* 4, *Corispermum* 4, *Camphorosma* 3, *Kochia* 3, *Petrosimonia* 3, *Polycnemum* 3, *Salsola* 3, *Bassia* 2, *Salicornia* 2, *Arthrocnemum* 1, *Ceratocarpus* 1, *Eurotia* 1, *Halocnemum* 1, *Noaea* 1. **B.** ħ/6 ɥ/12 ⊙/45. **C.** N/3 Ch/4 H/11 Th/45. **D.** 9/13 16/3 18/45. **E.** 3/10 7/7 8/29 9/12 11/5 13/17 14/2 16/23. The habitat of *Camphorosma ruthenica* M. B. is unknown. **F.** 1/31 2/33 3/28 4/6 5a/3 5b/2. **G.** 4/1 5/5 6/8 7/48 8/56 9/50 10/15 11/3. The predominance of flowering in mid and late summer is noteworthy. The flowering periods of *Camphorosma ruthenica* M. B. and *Suaeda heterophylla* Kar. et Kyr. are unknown. **H.** 1/15 2/30 2a/20 3/21 4/9 4a/13 5/18 6/12 6a/27 6b/5 7/35 8/30 8a/27 8b/12 9/40 10/29 10a/2 11/13 12/14 13/16 14/24 15/24 16/28. The majority of species occur in the Dobruja, and this in spite of its relatively small size. This is mainly due to the halophytes which reach this area from South Russia but do not extend beyond it, or only into Bulgaria and Thrace, and sometimes one additional area. **I.** I./9 I.a/1 II./10 III./32 IV./1 VI./4 XII./1 XIII./2 XIV./1 XIV.a/2 XVIII./4 XX./1. These figures are misleading without explanation. Relative to the Balkan Peninsular distribution, as distinct from the absolute general distribution, the figure for XIII. should be much increased and that for III. much reduced. This is because the main halophytic invasion has been one of Central Asian species via South Russia, as indicated by the present distribution of the species. The true 'wides' (I to III. inclusive) are species of *Atriplex* and *Chenopodium* found in ruderal places as weeds of cultivated ground. On this basis the figure for XIII. should be 10. The only accepted

endemic is *Beta nana* Boiss. et Heldr., which is a high mountain plant of Mt. Parnassus and Mt. Taygetus.

Amarantaceae. 7 species.

A. *Amarantus* 7. **B.** 4/1 ①/6. **C.** Ch(?)/1 Th/6. **D.** 9(?)/1 18/6. **E.** 13/5 16/7. **F.** 2/7 3/7. **G.** 5/1 6/1 7/7 8/7 9/7 10/5. **H.** 1/2 2/6 2a/2 3/5 4/2 5/4 6/3 6a/5 6b/1 7/6 8/5 8a/5 8b/1 9/2 10/3 10a/2 11/3 12/5 13/5 14/4 15/4 16/5. **I.** I./3 I.a/1 II./3. Probably all of the species of this family are of American origin, but they are now such an important element in the ruderal and weed flora of the Balkan Peninsula that I felt bound to include them. I believe hybridization occurs frequently between the different species in South Europe, leading to the segregation of new types.

Cynocrambaceae. 1 species.

A. *Theligonum* 1. **B.** ①/1. **C.** Th/1. **D.** 18/1. **E.** 9/1 11/1 13/1 15/1 16/1. **F.** 2/1 3/1. **G.** 1/1 2/1 3/1 4/1 5/1 12/1. **H.** 1/1 2/1 3/1 4a/1 5/1 6b/1 7/1 8b/1 11/1 13/1 14/1 16/1. **I.** VI./1. The one species, *Theligonum cynocrambe* L., is essentially Mediterranean in its general distribution and also within the Balkan Peninsula.

Phytolaccaceae. 1 species.

A. *Phytolacca* 1. **B.** 4/1. **C.** H/1. **D.** 16/1. **E.** 3/1 16/1. **F.** 2/1 3/1. **G.** 7/1 8/1 9/1. **H.** 1/1 2/1 3/1 5/1 6a/1 6b/1 7/1 8/1 8a/1 10/1 11/1 12/1 13/1 14/1 16/1. **I.** II./1. The one species, *Phytolacca americana* L.,is probably of North American origin but has become naturalized in most of the major districts.

Aizoaceae. 5 species.

A. *Mesembryanthemum* 2, *Aizoon* 1, *Glinus* 1, *Mollugo* 1. **B.** ①/5. **C.** Th/5. **D.** 18/5. **E.** 7/1 8/4 11/1 13/1 16/3. The habitat of *Aizoon hispanicum* L. is unknown. **F.** 1/3 2/5 3/1. **G.** 4/4 5/3 6/3 7/4 8/2 9/2. **H.** 1/3 2/3 2a/4 3/2 5/1 6a/1 6b/1 7/2 8/1 14/2. **I.** I.a/2 V./3 XVIII./1. The general distribution of the species is either very wide or Mediterranean Regional. Within the Balkan Peninsula the species are almost limited to the Mediterranean domain.

Portulacaceae. 2 species.

A. *Montia* 1, *Portulaca* 1. **B.** ①/2. **C.** Th/2. **D.** 18/2. **E.** 7/2 8/1 13/1. **F.** 2/2 3/2 4/1. **G.** 5/2 6/2 7/2 8/1 9/1. **H.** 1/1 2/2 2a/1 3/2 4/1 4a/1 5/1 6/2 6a/2 7/2 7a/1 8/1 8a/2 9/1 10/2 11/2 12/2 13/2 14/1 15/1 16/1. **I.** I./1 II./2. *Montia fontana* L. apparently does not occur in the extreme south, north, or north-east of the Balkan Peninsula, but *Portulaca oleracea* L. has a very wide distribution both within and without the Balkan Peninsula.

Caryophyllaceae. 418 species.

A. *Silene* 103, *Dianthus* 101, *Cerastium* 31, *Minuartia* 31, *Arenaria* 19, *Gypsophila* 15, *Moehringia* 12, *Tunica* 12, *Heliosperma* 9, *Paronychia* 8, *Scleranthus* 8, *Melandrium* 7, *Sagina* 7, *Saponaria* 7, *Herniaria* 6, *Spergularia* 6, *Stellaria* 6, *Buffonia* 3, *Kohlrauschia* 3, *Moenchia* 3, *Viscaria* 3, *Agrostemma* 2, *Lychnis* 2, *Spergula* 2, *Velezia* 2, *Corrigiola* 1, *Cucubalus* 1, *Drypis* 1, *Holosteum* 1, *Illecebrum* 1, *Myosoton* 1, *Polycarpon* 1, *Queria* 1, *Telephium* 1, *Vaccaria* 1. **B.** 4/299 ②/16 ①/120. **C.** Ch/190 H/166 Th/120. I have found considerable difficulty in deciding to which life-form many of the species in this family belong. There is no doubt that in many species individual plants may be either chamaephytes or hemicryptophytes, and I have counted such into both categories. The category of *Silene viscariopsis* Bornm. has not been determined. **D.** 9/105 12/170 13/6 16/113 18/120. The remarks under **C.** partly apply here. **E.** 3/10 4/1 5/26 6/41 7/110 8/52 9/149 10/6 11/131 13/29 14/15 15/1 16/6. The habitats of 18 species are unknown. The preference of the species for dry stony and rocky habitats is remarkable. Thus 9 has 148 species and 11 has 129. The grassy places come next with 109 species. **F.** 1/27 2/122 3/214 4/176 5a/82 5b/101 5c/43. Most species occur in the hill zone, but the number of species, 101, in the middle high mountain zone is noteworthy. The altitudinal limits of 9 species are unknown. **G.** 1/1 2/4 3/26 4/84 5/178 6/254 7/273 8/155 9/25 10/5 11/3 12/2. The number of species flowering each month rises to a maximum of 273 in July and after August falls very rapidly. The flowering periods of 23 species are unknown. **H.** 1/71 2/177 2a/55 3/120 4/63 4a/26 5/124 6/147 6a/133 6b/31 7/105 7a/16 8/142 8a/91 8b/132 9/75 10/132 10a/14 11/121 12/122 13/109 14/99 15/100 16/71. A majority of the species occurs in Greece where there are many endemics. Many species have a very limited distribution within the Balkan Peninsula. Thus 98 species, just over 23 per cent. of the whole family, occur in one area only. **I.** I./9 I.a/5 II./7 III./37 IV./13 V./15 VI./41 VII./1 VIII./20 IX./5 X./10 XI./28 XII./25 XIII./15 XIV./18 XIV.a/10 XV./14 XVIII./44 XIX./33 XX./175. The number of endemics is 175 or 41·5 per cent. of the whole. This is very high for so large a family. *Dianthus* has 63 endemics (or 61·7 per cent. of its species) and *Silene* 46 (or 44·2 per cent. of its species). There are relatively few species with a wide distribution, namely 58. The Mediterranean species number 120, excluding endemics and Balkan Peninsular types (XIX.).

Nymphaeaceae. 4 species.

A. *Nuphar* 2, *Nymphaea* 2. **B.** 4/4. **C.** HH/4. **D.** 19/4. **E.** 2/4. **F.** 2/3 3/1 4/1. **G.** 5/2 6/4 7/4 8/2. **H.** 2/2 3/2 4/2 4a/1 5/2 6/2 6a/2 7/2 8/2 8a/1 9/3 10/2 11/3 12/1 13/2 14/2 15/2 16/2. **I.** III./3 IV./1 V./1 XVIII./1. All 4 species have a wide, or rather wide, general distribution, but 2 of them are restricted to 1 district each in the Balkan Peninsula. *Nuphar pumilum* DC. is known only from Montenegro, and *Nymphaea candida* Presl only from the Dobruja. None of the species occurs in Crete.

Ceratophyllaceae. 3 species.

A. *Ceratophyllum* 3. **B.** 4/3. **C.** HH/3. **D.** 19/3. **E.** 2/3. **F.** 2/3. **G.** 6/3 7/3 8/2 9/2. **H.** 2/1 2a/1 3/2 5/1 6/2 6a/2 7/1 8/1 8a/2 9/3 10/2 11/1 12/1 14/2 16/2. **I.** I./1 IV./1 XII./1 XVIII./1. *Ceratophyllum platycantha* Chamiss. is recorded only from the Dobruja, while the other two species have wider distributions within the Balkan Peninsula. No species is known from Crete.

Ranunculaceae. 195 species.

A. *Ranunculus* 76, *Delphinium* 20, *Anemone* 17, *Aconitum* 15, *Aquilegia* 10, *Thalictrum* 10, *Helleborus* 9, *Clematis* 8, *Adonis* 7, *Nigella* 6, *Paeonia* 6, *Caltha* 4, *Myosurus* 2, *Actaea* 1, *Callianthemum* 1, *Eranthis* 1, *Isopyrum* 1, *Trollius* 1. **B.** ħ/7 4/145 ②/1 ①/44. **C.** M/6 Ch/1 H/122 G/17 HH/15 Th/44. **D.** 5/7 16/123 17/17 18/44 19/8. **E.** 2/5 3/17 4/1 5/36 6/52 7/52 8/3 9/65 10/10 11/15 12/3 13/28 14/3 15/1 16/4. The habitats of 7 species are unknown. **F.** 2/69 3/125 4/90 5a/47 5b/42 5c/22. The altitudinal limits of *Ranunculus brattius* Beck are unknown. The majority of the species occur in the hill zone, and this is correlated with the preference of the species for dry stony places, grassy places, and brushwood, as seen under **E.** **G.** 1/4 2/10 3/38 4/67 5/95 6/94 7/62 8/25 9/5 10/1 11/2 12/1. The flowering periods of 24 species are unknown. May and June see most species in flower. **H.** 1/31 2/68 2a/23 3/46 4/16 4a/23 5/59 6/63 6a/57 6b/13 7/65 7a/2 8/79 8a/57 8b/51 9/36 10/87 10a/8 11/77 12/64 13/56 14/69 15/77 16/64. Serbia, North Bulgaria, Montenegro, Croatia, Dalmatia, and Greece, in the order named, have most species. **I.** II./4 III./39 IV./6 V./13 VI./21 VIII./7 X./5 XI./19 XII./40 XIII./2 XIV./8 XIV.a/7 XV./12 XVIII./36 XIX./10 XX./37. Forty species are Central European in their general distribution, but for the Balkan Peninsula taken alone this number should be increased by some species from the 39 under III., since many of these have probably entered the Balkan Peninsula from Central Europe, though they have a distribution beyond this, mostly to (or from) Central Asia. The total of the

Mediterranean species is 65. The species occurring in only one of my Balkan Peninsular districts number 40 or 20·4 per cent. The endemics number 37 or 18·8 per cent.

Berberidaceae. 6 species.

A. *Berberis* 2, *Epimedium* 2, *Leontice* 2. **B.** ħ/2 ɥ/4. **C.** N/2 G/4. **D.** 4/2 17/4. **E.** 5/2 6/5 9/1 13/1. **F.** 2/2 3/5 4/3 5a/3 5b/1. **G.** 1/1 2/1 3/1 4/3 5/5 6/1. **H.** 1/2 2/3 2a/2 3/2 5/2 6/1 6a/1 6b/1 7/3 7a/1 8/1 8a/2 8b/1 9/2 10/2 11/1 12/2 13/1 14/1 15/2 16/1. **I.** III./1 IV./1 X./1 XI./2 XII./1 XIV.a/1 XVIII./2 XIX./1. The detailed distribution of the individual species of this family is of considerable interest. *Berberis cretica* L. occurs in Crete, Greece, the Cyclades, Thessaly, the Athos Peninsula, and the Thracian Islands. Outside the Balkan Peninsula it is only known from the Lebanon. *B. vulgaris* L. has a fairly wide distribution within and without our area, but is not known from Crete. *Epimedium alpinum* L. is recorded from Albania, Serbia, Bosnia, and South Croatia. *E. pubigerum* Mor. et DC., which occurs in Thrace and eastern South Bulgaria, is essentially a Pontic and Caucasian species. *Leontice altaica* Pall. is known from Greece (Achaia) and the Dobruja within the Peninsula, and has a wide distribution to (or from) Central Asia. *L. leontopetalum* L. is known from Crete, Greece, the Cyclades, Thessaly, South Macedonia, and Thrace, and has a general Oriental distribution.

Lauraceae. 1 species.

A. *Laurus* 1. **B.** ħ/1 ħ/1. **C.** MM/1 M/1. **D.** 1/1 3/1. **E.** 5/1 6/1. **F.** 2/1 3/1. **G.** 3/1 4/1. **H.** 1/1 2/1 3/1 4/1 5/1 6b/1 7/1 13/1 14/1 15/1 16/1. **I.** V./1 XVIII./1. *Laurus nobilis* L. is limited, in our area, to districts bordering on the Mediterranean and its branches.

Papaveraceae. 52 species.

A. *Fumaria* 17, *Corydalis* 13, *Papaver* 13, *Hypecoum* 4, *Glaucium* 3, *Chelidonium* 1, *Roemeria* 1. **B.** ɥ/16 ②/1 ①/38. **C.** H/7 G/9 Th/38. **D.** 16/8 17/9 18/38. **E.** 5/5 6/13 7/1 8/3 9/15 11/6 12/1 13/22 14/6 15/3 16/6. The habitats of *Fumaria flabellata* Gasp., *Papaver stipitatum* Fedde, and *P. tenuissimum* Fedde are unknown. The considerable number (20) of weeds of cultivated ground is mainly accounted for by the species of *Fumaria* and *Papaver*. **F.** 1/3 2/33 3/41 4/13 5a/4 5b/4 5c/2. The altitudinal limits of *Fumaria flabellata* Gasp. are unknown. **G.** 3/18 4/33 5/37 6/20 7/8 8/2 9/1. The flowering periods of 6 species are unknown. **H.** 1/14 2/32 2a/14 3/13 4/8 4a/8 5/15 6/23 6a/22 6b/3 7/20 7a/1 8/19 8a/17 8b/9 9/15 10/19 10a/2 11/13 12/8 13/12 14/24 15/16 16/19. Most species occur in Greece, Dalmatia, North Macedonia, and South Macedonia. **I.** II./1 III./6 V./10 VI./7

IX./1 X./1 XI./5 XII./10 XIII./1 XIV.a/1 XV./1 XVII./1 XVIII./11 XIX./3 XX./10. Twenty-four species are Mediterranean, excluding the 10 endemics, most of which are also Mediterranean in location and relationship.

Cruciferae. 344 species.

A. *Alyssum* 47, *Erysimum* 26, *Arabis* 22, *Thlaspi* 19, *Cardamine* 15, *Draba* 12, *Barbarea* 11, *Malcolmia* 11, *Nasturtium* 11, *Iberis* 10, *Lepidium* 10, *Hesperis* 9, *Sisymbrium* 9, *Brassica* 8, *Aubrietia* 7, *Dentaria* 7, *Isatis* 6, *Matthiola* 6, *Berteroa* 5, *Capsella* 5, *Camelina* 4, *Diplotaxis* 4, *Fibigia* 4, *Lunaria* 4, *Ptilotrichum* 4, *Sinapis* 4, *Aethionema* 3, *Biscutella* 3, *Crambe* 3, *Raphanus* 3, *Rapistrum* 3, *Turritis* 3, *Bunias* 2, *Clypeola* 2, *Conringia* 2, *Coronopus* 2, *Crenularia* 2, *Enarthrocarpus* 2, *Erucastrum* 2, *Hutchinsia* 2, *Lobularia* 2, *Peltaria* 2, *Schivereckia* 2, *Teesdalia* 2, *Vesicaria* 2, *Alliaria* 1, *Arabidopsis* 1, *Cakile* 1, *Calepina* 1, *Cheiranthus* 1, *Chorispora* 1, *Degenia* 1, *Didesmus* 1, *Eruca* 1, *Erucaria* 1, *Euclidium* 1, *Kernera* 1, *Lepidotrichum* 1, *Moricandia* 1, *Myagrum* 1, *Petrocallis* 1, *Ricotia* 1, *Subularia* 1, *Vella* 1, *Vogelia* 1. **B.** 4/189 ②/58 ①/117. **C.** Ch/65 H/172 G/7 HH/7 Th/117. **D.** 9/48 12/31 14/5 16/167 17/7 18/117. **E.** 3/25 4/1 5/33 6/18 7/52 8/22 9/127 10/5 11/108 12/1 13/43 14/6 15/5 16/40. The preference for stony and rocky habitats is marked. The habitats for five species are unknown. **F.** 1/26 2/112 3/212 4/151 5a/73 5b/74 5c/41. The greatest concentration of species is in the hill and montane regions. The altitudinal limits of 4 species are unknown. **G.** 1/5 2/15 3/62 4/151 5/221 6/196 7/114 8/36 9/12 10/4 11/4 12/4. Most species are flowering in May and June. The flowering periods of 17 species are unknown. **H.** 1/61 2/157 2a/52 3/106 4/59 4a/43 5/96 6/135 6a/113 6b/33 7/102 7a/7 8/119 8a/87 8b/91 9/81 10/124 10a/8 11/120 12/102 13/83 14/125 15/108 16/86. Sixty-five species are limited to one area, and of these 39 are endemics. Most species occur in Greece, which has 157. North Macedonia has 135, Dalmatia, 125, Serbia 124, and North Bulgaria 119. No general conclusions have been drawn from the numbers of species distributed in the different areas. **I.** I./4 II./6 III./25 IV./15 V./26 VI./38 VIII./22 IX./9 X./6 XI./34 XII./62 XIII./8 XIV./11 XIV.a/4 XV./12 XVII./1 XVIII./63 XIX./28 XX./94. The 'wides' (I. to III.) number only 35 or just over 10 per cent. The Mediterranean species total 135 or 39 per cent., excluding the Balkan Peninsular types (XIX.), and the endemics (XX.). The last number 94 or 27 per cent. The Central European species, as here limited, number 62 or 17·6 per cent.

Capparidaceae. 3 species.

A. *Capparis* 2, *Cleome* 1. **B.** ħ/2 ①/1. **C.** N/2 Th/1. **D.** 4/2 18/1. **E.** 9/2 11/1 13/2 16/2. **F.** 2/3 3/2. **G.** 5/2 6/2 7/2 8/2. The flowering

period of *Cleome aurea* Čel. is unknown. **H.** 1/2 2/2 2a/1 3/1 5/1 6/1 6a/3 6b/1 7/2 8a/1 8b/1 11/1 14/2 15/1 16/2. **I.** V./1 VIII./1 XX./1. The 3 species are all essentially Mediterranean both within and without the Balkan Peninsula. The relict species *Cleome aurea* Čel. occurs in South Macedonia, the Athos Peninsula, Thrace, South Bulgaria, and the Rodope massif.

Resedaceae. 8 species.

A. *Reseda* 8. **B.** 4/3 ②/3 ①/4. **C.** Ch/1 H/5 Th/4. **D.** 9/1 16/5 18/4. **E.** 7/3 8/1 9/4 11/1 13/3 14/2 16/1. **F.** 2/2 3/7 4/3. **G.** 3/2 4/4 5/8 6/7 7/4 8/1. **H.** 1/3 2/5 2a/4 3/4 4/2 4a/2 6/5 6a/4 6b/2 7/3 8/3 8a/2 8b/2 9/4 10/4 11/3 12/2 13/4 14/5 15/3 16/3. **I.** V./2 VI./1 VIII./1 X./1 XII./3 XIII./1 XIV./1 XIV.a/1 XVIII./2 XX./1. The majority of species are Mediterranean in general distribution and, with one exception, they all occur within the Mediterranean domain of the Balkan Peninsula, even if they are not limited to it.

Droseraceae. 3 species.

A. *Drosera* 2, *Aldrovanda* 1. **B.** 4/3. **C.** H/2 HH/1. **D.** 14/2 19/1. **E.** 2/1 4/2. **F.** 2/1 4/1 5a/1 5b/2. **G.** 6/1 7/2 8/1. **H.** 6/2 6a/1 8/1 8b/1 9/1 10/2 14/1. **I.** I.a/1 II./2. The three species have all a wide general distribution. Within the Balkan Peninsula *Aldrovanda vesiculosa* L. occurs in North and South Macedonia, the Dobruja, and Serbia; *Drosera anglica* Huds. is recorded from North Macedonia and Dalmatia; and *D. rotundifolia* L. for North Bulgaria, the Rodope massif, and Serbia.

Crassulaceae. 60 species.

A. *Sedum* 38, *Sempervivum* 13, *Cotyledon* 7, *Tillaea* 2. **B.** 4/43 ②/1 ①/16. **C.** Ch/33 H/11 Th/16. **D.** 9/5 12/33 14/3 16/11 18/16. **E.** 3/1 5/1 6/2 8/5 9/25 10/1 11/41. The habitats of *Sedum cotyledon* Sieb. and *S. villosum* L. are unknown. **F.** 1/4 2/21 3/27 4/33 5a/20 5b/17 5c/7. The altitudinal limits of 4 species are unknown. **G.** 1/1 2/1 3/3 4/10 5/20 6/34 7/27 8/14 9/2. The flowering periods of 10 species are unknown. **H.** 1/23 2/31 2a/11 3/24 4/7 4a/8 5/19 6/27 6a/22 6b/13 7/17 7a/2 8/27 8a/16 8b/21 9/5 10/21 10a/2 11/19 12/15 13/16 14/19 15/14 16/11. **I.** III./2 IV./5 V./1 VI./12 VIII./2 X./6 XI./3 XII./12 XIII./1 XIV./3 XV./3 XVIII./6 XIX./3 XX./16.

The species of *Cotyledon* are essentially Mediterranean in general and Balkan Peninsular distribution. All types of distribution are found amongst the species of *Sedum*, while those of *Sempervivum* are mainly Central European, at least in type, with a strong endemic element, but *S. arboreum* L. is Mediterranean (VI.) and occurs in Crete, Greece, and Corfu in our area. Bulgaria is particularly rich in

species of *Sedum*. The two species of *Tillaea* are essentially Mediterranean within the Balkan Peninsula.

Saxifragaceae. 45 species.

A. *Saxifraga* 38, *Ribes* 5, *Chrysosplenium* 1, *Parnassia* 1. **B.** ♄/5 ♃/34 ②/2 ①/4. **C.** N/5 Ch/25 H/15 Th/4. **D.** 4/5 7/1 9/6 12/21 13/7 16/15 18/4. **E.** 3/3 5/4 6/2 9/16 10/9 11/30. **F.** 3/9 4/20 5a/19 5b/23 5c/30. **G.** 3/2 4/6 5/13 6/26 7/29 8/12 9/4. The flowering periods of 4 species are unknown. **H.** 1/3 2/18 2a/2 3/13 4/10 4a/2 5/20 6/19 6a/11 6b/6 7/2 8/14 8a/3 8b/28 9/1 10/20 10a/2 11/26 12/20 13/16 14/9 15/16 16/10. **I.** II./8 III./2 IV./2 VI./2 IX./2 X./1 XII./12 XIV./2 XV./15 XVIII./6 XIX./4 XX./9. A majority of the species of *Saxifraga* occur in the montane and high mountain zones, and correlated with this the general distribution of a majority of our species includes the mountains of Central Europe. The historical significance of the distribution of the high mountain plants of our area is discussed elsewhere (p. 413). All 9 endemics are species of *Saxifraga*.

Platanaceae. 1 species.

A. *Platanus* 1. **B.** ♄/1 ♅/1. **C.** MM/1 M/1. **D.** 2/1. **E.** 5/1 6/1. **F.** 2/1 3/1 4/1. **G.** 3/1 4/1 5/1. **H.** 1/1 2/1 2a/1 3/1 5/1 6/1 6a/1 6b/1 7/1 8a/1 8b/1. **I.** XI./1. *Platanus orientalis* L. is certainly native to our area, but it is difficult to determine its exact natural range, because it has been much planted, especially near springs and wells.

Rosaceae. 188 species.

A. *Potentilla* 41, *Rosa* 34, *Rubus* 20, *Prunus* 15, *Pyrus* 13, *Alchemilla* 9, *Crataegus* 9, *Geum* 9, *Poterium* 7, *Cotoneaster* 5, *Spiraea* 4, *Fragaria* 3, *Sanguisorba* 3, *Agrimonia* 2, *Amelanchier* 2, *Filipendula* 2, *Waldsteinia* 2, *Aremonia* 1, *Aruncus* 1, *Comarum* 1, *Cydonia* 1, *Dryas* 1, *Mespilus* 1, *Sibbaldia* 1, *Sibiraea* 1. **B.** ♄/23 ♅/91 ♃/84 ①/1. **C.** MM/6 M/43 N/54 Ch/2 H/100 Th/1. **D.** 2/22 3/3 4/41 5/49 7/66 9/2 16/80 18/1. **E.** 3/3 5/60 6/70 7/42 8/3 9/43 10/2 11/36 13/3 14/2 16/2. The habitats of 6 species are unknown. **F.** 2/45 3/100 4/111 5a/55 5b/35 5c/21. The altitudinal limits of *Potentilla gaillardotii* Boiss., *Rosa montana* Chaix, and *R. orphanidis* Boiss. et Reut. are unknown. **G.** 1/1 2/1 3/16 4/39 5/83 6/111 7/91 8/43 9/11. The flowering periods of 8 species are unknown. **H.** 1/20 2/65 2a/12 3/68 4/40 4a/13 5/74 6/61 6a/62 6b/25 7/46 7a/7 8/92 8a/41 8b/80 9/38 10/104 10a/19 11/95 12/103 13/86 14/51 15/85 16/80. **I.** I./1 II./11 III./32 IV./12 V./14 VI./22 VIII./10 IX./2 X./4 XI./12 XII./56 XIII./5 XIV./3 XIV.a/8 XV./14 XVIII./51 XIX./8 XX./24. The predominance of Central European species and the relatively small numbers of endemics are striking features. The former number 56 or 29 per cent. and the

latter 24 or 12·5 per cent. of the total species. The Mediterranean species total 64 or 32·2 per cent. Many of the 'wides' are of northern origin so far as the Balkan Peninsula is concerned. The following species deserve individual mention. *Cotoneaster nummularia* Fisch. et Mey., an Oriental and Caucasian species, reaches Mt. Drakona in Crete. *Crataegus azarolus* L., essentially a Mediterranean Regional species, has, in our area, the discontinuous distribution Crete, Dalmatia, and South Croatia. *Sibbaldia procumbens* L., a plant of wide general distribution, is known only from North Macedonia and the Rodope massif in our area. The endemic *Sibiraea croatica* Degen is a relict type of Hercegovina and South Croatia. *Waldsteinia geoides* Willd. and *W. ternata* Fritsch are known respectively from North Bulgaria, Serbia, and Novi Pazar, and from Serbia. Nine species of *Geum* are known from Bulgaria, including 2 Balkan Peninsular endemics and *G. rhodopeum* Stoy. et Stef., which is only recorded from the Rodope. Various hybrids between the species have been named.

Leguminosae. 545 species.

A. *Trifolium* 94, *Astragalus* 70, *Vicia* 52, *Genista* 33, *Cytisus* 30, *Medicago* 28, *Lathyrus* 27, *Ononis* 21, *Onobrychis* 20, *Lotus* 20, *Orobus* 16, *Trigonella* 14, *Coronilla* 13, *Melilotus* 12, *Lupinus* 9, *Anthyllis* 8, *Hedysarum* 8, *Oxytropis* 7, *Hippocrepis* 6, *Dorycnium* 5, *Argyrolobium* 4, *Cicer* 4, *Laburnum* 4, *Scorpiurus* 4, *Tetragonolobus* 4, *Lens* 3, *Calycotome* 2, *Ebenus* 2, *Glycyrrhiza* 2, *Ornithopus* 2, *Pisum* 2, *Sophora* 2, *Adenocarpus* 1, *Alhagi* 1, *Anagyris* 1, *Biserrula* 1, *Caragana* 1, *Ceratonia* 1, *Cercis* 1, *Colutea* 1, *Galega* 1, *Gonocytisus* 1, *Hammatolobium* 1, *Hymenocarpus* 1, *Lotononis* 1, *Petteria* 1, *Psoralea* 1, *Securigera* 1, *Spartium* 1. **B.** ♄/2 ♅/102 ♃/206 ☉/15 ☿/228. **C.** M/8 N/54 Ch/74 H/208 G/4 Th/228. **D.** 1/1 2/3 3/1 4/42 6/6 7/28 9/67 12/4 14/6 16/204 17/4 18/228. **E.** 3/15 5/59 6/114 7/189 8/57 9/221 10/2 11/57 13/73 14/10 15/7 16/24. The habitats of 18 species are unknown. **F.** 1/26 2/257 3/374 4/187 5a/77 5b/60 5c/36. The altitudinal limits of 4 species are unknown. **G.** 1/2 2/6 3/100 4/231 5/362 6/307 7/199 8/76 9/8 10/1 11/1 12/0. The flowering periods of 21 species are unknown. A majority of species flower in the early summer, May and June. **H.** 1/147 2/288 2a/135 3/157 4/100 4a/96 5/183 6/207 6a/205 6b/81 7/241 7a/10 8/191 8a/158 8b/134 9/99 10/179 10a/29 11/201 12/155 13/165 14/244 15/167 16/184. 109 species, or 20 per cent., occur in only one district each. The family is an important one in the flora of all the districts, but is especially well represented in those which belong to the Mediterranean domain. Thus Greece has 288 species, Dalmatia 244, and Thrace 241. A considerable number of Asia Minor species just reach our area in Thrace.

Examples are *Gonocytisus angulatus* Spach and *Hedysarum varium* Willd. **I.** III./46 IV./20 V./58 VI./119 VII./6 VIII./43 IX./9 X./67 XI./16 XII./43 XIII./26 XIV/18 XIV.a/9 XV./9 XVIII./125 XIX./29 XX./106. The 'wides' under III. number 46 or only 8·4 per cent. The total Mediterranean element, excluding Balkan Peninsular types and endemics, consists of 318 species or 58 per cent. The endemics number 106 or 19 per cent. The southern predominance of the family is also noticed above. The detailed distribution of many species and genera is of interest. *Adenocarpus complicatus* J. Gay is known from Greece and the Athos Peninsula. Thirty-one of the 70 species of *Astragalus* are endemic, and most of these show an Oriental affinity. *Caragana frutescens* Med. is known in our area only from North Bulgaria. *Ebenus cretica* L. is endemic to Crete and *E. sibthorpii* DC., distributed in the eastern Mediterranean Basin, is known from Greece, Thessaly, and the Athos Peninsula. The genera *Cytisus* and *Genista* are represented by 30 and 33 species respectively and have each many endemics. *Petteria ramentacea* Presl is endemic to Albania, Montenegro, Bosnia, Hercegovina, and Dalmatia. *Sophora alopecuroides* L. is known only from the Dobruja and *S. reticulata* Hayek only from Thrace within our area. We have here apparently an example of invasion by different species of the same genus from two different directions. *Tetragonolobus biflorus* Desr., an Oriental species, is known only from Epirus in our area. The genus *Trifolium*, with 94 species, has 22 endemics. *Vicia* with 52 species has only 5 endemics.

Geraniaceae. 44 species.

A. *Geranium* 28, *Erodium* 15, *Biebersteinia* 1. **B.** 4/23 ②/4 ①/20. **C.** H/25 G/2 Th/20. **D.** 14/2 16/24 17/2 18/20. **E.** 5/12 6/10 7/19 8/5 9/8 11/10 13/2 16/2. The habitat of *Biebersteinia orphanidis* Boiss. is unknown. **F.** 1/2 2/20 3/25 4/24 5a/13 5b/14 5c/2. **G.** 1/2 2/2 3/10 4/18 5/30 6/30 7/24 8/11 9/3 11/2 12/2. The flowering periods of *Erodium hoefftianum* C. A. Mey., *E. serotinum* Stev., and *Geranium caeruleatum* Schur are unknown. **H.** 1/11 2/29 2a/16 3/21 4/7 4a/15 5/24 6/24 6a/19 6b/4 7/22 8/18 8a/16 8b/16 9/16 10/21 10a/3 11/22 12/20 13/20 14/24 15/18 16/17. Four species occur each in only 1 area. **I.** I./2 III./10 IV./2 V./5 VI./7 VIII./2 IX./2 X./2 XI./1 XII./6 XIII./1 XIV./1 XIV.a/3 XV./1 XVIII./11 XIX./1 XX./5. The species are fairly equally distributed amongst the different districts within the Balkan Peninsula and have very various general distributions. The endemics number only 5 or 11·3 per cent. *Biebersteinia orphanidis* Boiss. is endemic to Greece and Asia Minor.

Oxalidaceae. 3 species.

A. *Oxalis* 3. **B.** 4/3. **C.** H/3. **D.** 14/2 16/1. **E.** 5/1 11/1 13/2 15/1 16/2. **F.** 2/2 3/2 4/1 5a/1. **G.** 1/1 2/1 3/1 4/2 5/2 6/1 7/1 8/1 9/1. **H.** 1/2 2/3 2a/1 3/2 4a/2 5/2 6/1 6a/2 7/2 7a/1 8/2 8b/2 10/2 11/2 12/1 13/2 14/1 15/2 16/2. **I.** I./1 III./1 VI./1. *Oxalis acetosella* L. and *O. corniculata* L. have each a wide general distribution and occur in a majority of the major districts of the Balkan Peninsula. *O. cernua* Thunb., of South African origin, is now widely spread in the Mediterranean Basin and occurs in Crete, Greece, and Corfu.

Linaceae. 39 species.

A. *Linum* 38, *Radiola* 1. **B.** ♄/2 4/28 ②/1 ①/9. **C.** N/2 Ch/20 H/16 Th/9. **D.** 4/2 9/9 12/13 16/16 18/9. **E.** 3/1 5/3 6/4 7/15 8/2 9/16 10/1 11/5 13/1 15/1 16/2. The habitats of 4 species are unknown. **F.** 1/1 2/8 3/25 4/20 5a/10 5b/8 5c/6. The altitudinal limits of *Linum euboeum* Bornm. are unknown. **G.** 4/7 5/16 6/27 7/23 8/6 9/1. The flowering periods of 6 species are unknown. **H.** 1/9 2/17 2a/6 3/14 4/4 4a/6 5/15 6/17 6a/12 6b/6 7/16 7a/1 8/15 8a/14 8b/12 9/7 10/17 11/14 12/9 13/16 14/15 15/16 16/13. Nine species are known from only 1 area each. **I.** III./1 IV./1 V./6 VI./4 VIII./2 IX./1 X./1 XII./3 XIII./2 XIV./1 XIV.a/1 XV./1 XVIII./13 XIX./4 XX./14. The species are fairly equally distributed amongst the Balkan Peninsular districts, but the Mediterranean general distribution is dominant, and, excluding Balkan Peninsular types and endemics, a total of 14 species show this. The endemic species number 14, or 36 per cent., and are all species of *Linum*, a majority of them being distinctly Mediterranean in their distribution or affinities.

Zygophyllaceae. 5 species.

A. *Zygophyllum* 2, *Fagonia* 1, *Peganum* 1, *Tribulus* 1. **B.** 4/3 ①/2. **C.** Ch/2 H/1 Th/2. **D.** 7/1 9/2 16/1 18/2. **E.** 8/1 9/2 13/2 16/2. The habitat of *Zygophyllum album* L. is unknown. **F.** 1/2 2/4 3/3. **G.** 4/2 5/3 6/4 7/3 8/2 9/2 10/2 11/1 12/1. **H.** 1/4 2/2 2a/2 3/2 4/1 4a/1 5/1 6/2 6a/1 7/2 8/2 9/3 10/2 12/1 13/1 14/1 15/1 16/1. **I.** I.a/1 III./2 VI./1 X./1 XVI./1 XVII./1. *Fagonia cretica* L. (Mediterranean Basin) and *Zygophyllum album* L. (eastern Mediterranean Basin and Egyptian) occur, in our area, only in Crete, and *Zygophyllum fabago* L. only in the Dobruja.

Rutaceae. 14 species.

A. *Ruta* 13, *Dictamnus* 1. **B.** 4/14. **C.** Ch/12 H/7. **D.** 9/11 16/7. **E.** 5/1 6/3 7/3 9/10 11/3 13/1 16/2. **F.** 2/7 3/13 4/5. **G.** 3/3 4/3 5/9 6/10 7/6. The flowering period of *Ruta balcanica* Graebn. is unknown. **H.** 1/3 2/5 2a/1 3/3 4/2 4a/1 5/7 6/5 6a/3 6b/1 7/6 8/4 8a/2 8b/4 9/3

10/4 11/3 12/3 13/4 14/5 15/5 16/5. Three species occur only in 1 area each. I. III./1 VI./2 VIII./1 IX./1 X./1 XIII./1 XIX./2 XX./5. More than half the species are either endemic or extend only a short distance beyond our borders. *Ruta buxbaumii* Poir., an eastern Mediterranean species, occurs in Crete and Thrace, probably owing to independent invasions.

Polygalaceae. 16 species.

A. *Polygala* 16. B. ♃/15 ①/1. C. Ch/14 H/12 Th/1. D. 9/4 12/10 16/12 18/1. E. 6/3 7/12 9/4 11/1. F. 2/3 3/8 4/8 5a/4 5b/3 5c/2. G. 3/1 4/4 5/8 6/10 7/7 8/2. H. 1/3 2/8 2a/2 3/4 4/2 4a/3 5/8 6/7 6a/5 6b/2 7/8 8/4 8a/8 8b/5 9/3 10/6 10a/1 11/7 12/8 13/6 14/6 15/5 16/6. Three species occur in only one district each. I. III./1 IV./1 VI./2 VIII./1 X./1 XI./3 XII./5 XV./1 XVIII./4 XIX./2 XX./4. The Mediterranean species total 8. The general and detailed distribution of the species suggests very strongly a divergence of Central European species from a Mediterranean group of species occurring in the Balkan Peninsula. The habitat, altitudinal limits, and flowering period of *Polygala crista-galli* Chod. are unknown.

Euphorbiaceae. 79 species.

A. *Euphorbia* 73, *Mercurialis* 3, *Chrozophora* 2, *Andrachne* 1. B. ♄/2 ♃/50 ①/21. C. Ch/41 H/21 G/4 Th/21. D. 7/2 9/27 12/20 16/14 17/4 18/21. E. 3/3 5/9 6/10 7/11 8/3 9/27 11/10 13/21 14/6 15/3 16/8. The habitats of *Euphorbia jacquinii* Fenzl and *E. montenegrina* Maly are unknown. F. 1/4 2/44 3/52 4/32 5a/11 5b/3 5c/1. The majority of species occur in the hill zone. The upper limits of about 4 species are uncertain. G. 1/2 2/6 3/17 4/31 5/48 6/48 7/35 8/13 9/9 10/5 11/3. The majority of species flower in May and June. The flowering periods of 6 species are unknown. H. 1/24 2/39 2a/21 3/24 4/9 4a/11 5/27 6/21 6a/35 6b/14 7/33 7a/3 8/27 8a/25 8b/16 9/17 10/34 10a/3 11/29 12/29 13/30 14/34 15/27 16/31. Ten species occur each in only one district. I. III./6 IV./2 V./5 VI./15 VII./1 VIII./5 IX./1 X./5 XI./5 XII./15 XIII./4 XIV./4 XIV.a/3 XVIII./19 XIX./5 XX./20. The Mediterranean species total 37, excluding Balkan Peninsular types and endemics. The endemics, all species of *Euphorbia*, number 20, or 25 per cent. The presence of several spinose species of *Euphorbia* is noteworthy. Thus *E. acanthothamnos* Heldr. et Sart. is a shrubby species widely distributed in Crete, Greece, the Cyclades, the Ionian Islands, South Macedonia, and the Athos Peninsula; *E. spinosa* L. is known from Albania, Montenegro, Hercegovina, Dalmatia, and Istria. Both species are dwarf suffruticose plants whose numerous branches become spiny at the ends. The spinescence is of quite a different kind from that of the fleshy tropical and subtropical African species.

Callitrichaceae. 7 species.

A. *Callitriche* 7. **B.** 4/7. **C.** HH/7. **D.** 19/7. **E.** 2/7 3/4. **F.** 1/1 2/6. **G.** 3/1 4/2 5/7 6/7 7/4 8/4 9/1. The flowering period of *Callitriche hamulata* Kütz. is unknown. **H.** 2/5 3/2 4a/3 5/2 6/1 7/2 8/2 8a/1 8b/1 10/2 11/4 14/4 15/13 16/2. **I.** I.a/1 III./1 IV./1 VI./1 VIII./2 XII./3 XVIII./1. *Callitriche hamulata* Kütz. is recorded only from Montenegro, and *C. obtusangula* Le Gall only from Greece (Argolis), within our area. No species is known to occur in Crete.

Buxaceae. 1 species.

A. *Buxus* 1. **B.** ħ/1. **C.** MM/1. **D.** 3/1. **E.** 5/1 6/1. **F.** 4/1 5a/1 5b/1. **G.** 3/1 4/1 5/1 6/1. **H.** 2/1 3/1 4/1 5/1 6/1 6a/1 7/1 14/1. **I.** III./1. *Buxus sempervirens* L. is especially dominant in brushwood on serpentine in the montane and lower high mountain zones in the west central districts of the Balkan Peninsula. It is not known south of Euboea, Thessaly, and Epirus, or in Bulgaria or the Dobruja.

Empetraceae. 1 species.

A. *Empetrum* 1. **B.** ħ/1. **C.** Ch/1 **D.** 3/1. **E.** 6/1 7/1. **F.** 5b/1 5c/1. **G.** 4/1 5/1. **H.** 8b/1 11/1 12/1. **I.** III./1. XV./1 The extreme south-eastern distribution of *Empetrum nigrum* L. occurs in the Rodope massif, though it is known also from the districts of Bosnia and Hercegovina.

Coriariaceae. 1 species.

A. *Coriaria* 1. **B.** ħ/1. **C.** M/1. **D.** 4/1. **E.** 6/1. **F.** 2/1 3/1. **G.** 4/1 5/1. **H.** 2/1. **I.** VI./1. The one species, *Coriaria myrtifolia* L., has only been recorded from the Peloponnese in our area.

Anacardiaceae. 5 species.

A. *Pistacia* 3, *Cotinus* 1, *Rhus* 1. **B.** ħ/1 ħ/5. **C.** MM/1 M/5. **D.** 2/1 3/1 4/4. **E.** 6/5. **F.** 2/4 3/5 4/2. **G.** 3/1 4/2 5/4 6/2. The flowering period of *Pistacia mutica* Fisch. et Mey. is unknown. **H.** 1/2 2/4 3/4 4/3 4a/1 5/4 6/3 6a/4 6b/3 7/4 8/2 8a/2 8b/2 9/1 10/1 11/3 12/1 13/4 14/4 15/3 16/3. **I.** VI./4 XI./1 XII./1 XVIII./3. All of the species are essentially Mediterranean though *Cotinus coggygria* Scop. extends into Central Europe. The species of *Pistacia* are characteristic macchia plants.

Aquifoliaceae. 1 species.

A. *Ilex* 1. **B.** ħ/1 ħ/1. **C.** M/1. **D.** 3/1. **E.** 3/1 5/1. **F.** 3/1 4/1. **G.** 5/1 6/1. **H.** 2/1 3/1 4/1 4a/1 5/1 6/1 6a/1 6b/1 7/1 8/1 8a/1 8b/1 10/1 11/1 12/1 13/1 14/1 15/1 16/1. **I.** IV./1 V./1 XVIII./1. *Ilex aquifolium* L. occurs in all the major areas except Crete and the Dobruja, but in Greece is only known from Mt. Dirphys in Euboea.

Celastraceae. 4 species.

A. *Euonymus* 4. **B.** ħ/4. **C.** N/2 M/4. **D.** 4/4. **E.** 5/2 6/1 11/1. **F.** 2/4 3/4 4/4. **G.** 4/1 5/4 6/2. **H.** 2/2 3/2 4a/1 5/2 6/4 6a/4 6b/1 7/1 8/3 8a/4 8b/4 9/2 10/3 11/3 12/3 13/2 14/2 15/2 16/3. **I.** III./2 XI./1 XII./2 XVIII./1 XX./1. Two species (*Euonymus europaeus* L. and *E. verrucosus* Scop.) are very wide in general distribution. The endemic *E. bulgaricus* Vel. occurs in North and South Macedonia, in South Bulgaria, and in the Rodope massif. No species is known from Crete.

Staphyleaceae. 1 species.

A. *Staphylea* 1. **B.** ħ/1. **C.** M/1. **D.** 4/1. **E.** 6/1. **F.** 2/1 3/1. **G.** 5/1. **H.** 8/1 8b/1 9/1 10/1 11/1 12/1 15/1 16/1. **I.** XI./1 XII./1 XVIII./1. *Staphylea pinnata* L. has a northern distribution in our area.

Aceraceae. 10 species.

A. *Acer* 10. **B.** ħ/9 ħ/5. **C.** MM/8 M/6. **D.** 2/9 4/5 7/1. **E.** 5/9 6/5 **F.** 2/3 3/4 4/9 5a/5. **G.** 4/6 5/9 6/1. The flowering period of *Acer bosniacum* Maly is unknown. **H.** 1/1 2/5 3/6 4/4 5/7 6/7 6a/7 6b/4 7/3 8/6 8a/3 8b/4 9/3 10/7 10a/1 11/7 12/8 13/8 14/6 15/6 16/4. One species is known from only 1 district. **I.** V./2 VI./2 VIII./1 X./2 XI./1 XII./3 XVIII./4 XIX./1 XX./2. Studies of the general and detailed distributions of the species yield the conclusion that the genus *Acer* is an old type in our area, where there has been some local development of species and varieties. The western districts are richest in species.

Hippocastanaceae. 1 species.

A. *Aesculus* 1. **B.** ħ/1. **C.** MM/1. **D.** 2/1. **E.** 5/1. **F.** 3/1 4/1. **G.** 5/1 6/1. **H.** 2/1 3/1 4/1 8/1. **I.** XI./1. *Aesculus hippocastanum* L. has an interesting discontinuous distribution in our area, where it is found in the Pindus range of northern Greece, Epirus, and Thessaly, and in North Bulgaria. Its main distribution is Oriental.

Balsaminaceae. 1 species.

A. *Impatiens* 1. **B.** ⊙/1. **C.** Th/1. **D.** 18/1. **E.** 5/1 6/1. **F.** 3/1 4/1 5a/1. **G.** 7/1 8/1 9/1. **H.** 6a/1 8/1 8a/1 8b/1 10/1 11/1 12/1 13/1 15/1 16/1. **I.** III./1. *Impatiens noli-tangere* L. is mainly northern in our area.

Rhamnaceae. 20 species.

A. *Rhamnus* 16, *Paliurus* 2, *Zizyphus* 2. **B.** ħ/20. **C.** M/6 N/20. **D.** 4/20 7/12. **E.** 5/1 6/10 9/8 11/9 14/1. The habitat of *Rhamnus guicciardii* Heldr. et Sart. is unknown. **F.** 2/8 3/11 4/9 5a/3 5b/2 5c/1. **G.** 3/2 4/4 5/12 6/12 7/5. The flowering period of 1 species is unknown to me. **H.** 1/5 2/11 2a/4 3/6 4/2 4a/4 5/12 6/8 6a/6

6b/3 7/4 8/6 8a/5 8b/7 9/4 10/5 11/8 12/6 13/7 14/8 15/1 16/7. Four species are known from only 1 area each. **I.** III./2 V./2 VI./1 VIII./1 X./1 XI./1 XII./2 XIV./1 XIV.a/1 XV./1 XVIII./2 XIX./2 XX./7. *Paliurus microcarpus* Wilmott from South Macedonia may be only a variety of the widely spread *P. spina-Christi* Mill., equivalent to the var. *apterus* Beck, which has been several times recorded in the Balkan Peninsula. The genus *Rhamnus* with 2 Balkan Peninsular and 6 endemic species shows a considerable local development. *R. graeca* Boiss. et Reut. occurs in Crete, Greece, and the Cyclades.

Vitaceae. 1 species.

A. *Vitis* 1. **B.** ħ/1. **C.** M/1 N/1. **D.** 5/1. **E.** 5/1 6/1. **F.** 2/1 3/1. **G.** 5/1 6/1. **H.** 1/1 2/1 3/1 4/1 5/1 6/1 6a/1 7/1 8a/1 8b/1 9/1 10a/1 12/1 13/1 14/1 15/1 16/1. **I.** V./1 XVIII./1. The vine certainly appears native in some parts of the Peninsula, and, as for the olive, a wild race has been given a specific name (*V. silvestris* Gmel.). It is interesting that this is most often dioecious, while the cultivated varieties are generally hermaphrodite. It is very difficult, however, to be sure of the true wild distribution of this plant.

Tiliaceae. 4 species.

A. *Tilia* 4. **B.** 5/4. **C.** MM/4. **D.** 2/4. **E.** 5/4 11/1. **F.** 3/3 4/4. **G.** 5/1 6/4 7/3. **H.** 2/2 3/2 4/1 4a/1 5/1 6/3 6a/4 6b/1 7/3 8/4 8a/1 8b/3 9/2 10/4 11/4 12/4 13/2 14/3 15/4 16/2. **I.** IV./1 VIII./1 XII./2 XVIII./1 XIX./1. The taxonomy of the limes, as of the elms, of the Balkan Peninsula cannot be satisfactorily understood until more collections and field studies have been made. This is especially true of the species (?) *Tilia rubra* DC. No species occurs in Crete.

Malvaceae. 30 species.

A. *Malva* 10, *Althaea* 9, *Lavatera* 6, *Abutilon* 1, *Hibiscus* 1, *Kitaibelia* 1, *Malope* 1, *Sida* 1. **B.** 4/15 ②/4 ①/12. **C.** Ch/3 H/19 Th/12. **D.** 9/3 16/19 18/12. **E.** 3/1 5/3 6/9 7/4 8/2 9/10 11/2 13/9 14/1 15/1 16/10. **F.** 2/26 3/23 4/6 5a/1 5b/1. A large majority of species occur in the lowland and hill zones. **G.** 3/2 4/13 5/17 6/18 7/19 8/10 9/5. The flowering period of *Althaea pontica* (Janka) is unknown. Most species are summer-flowering (May to July). **H.** 1/14 2/22 2a/12 3/15 4/5 4a/10 5/11 6/14 6a/15 6b/3 7/16 8/13 8a/11 8b/9 9/10 10/16 10a/2 11/13 12/10 13/12 14/19 15/11 16/14. The species are well distributed in the different districts; 2 species are limited to 1 area (Thrace). **I.** III./5 IV./1 V./4 VI./6 VIII./3 IX./1 X./3 XI./2 XII./4 XIV./1 XIV.a/1 XVIII./9 XIX./3 XX./2. The very widely distributed species number only 5. The Mediterranean species total 19,

excluding Balkan Peninsular and endemic species, and no species is entirely Central European within and without the Balkan Peninsula. *Althaea taurinensis* DC. occurs in North Macedonia, South Bulgaria, Serbia, Dalmatia, and Istria, and extends beyond our borders into North Italy and Hungary. *Kitaibelia vitifolia* Willd. is known from Serbia and Bosnia and has a general Pannonian distribution. *Malva ambigua* Guss. is known from Greece, the Cyclades, and Istria.

Hypericaceae. (Guttiferae p.p.) 52 species.

A. *Hypericum* 52. **B.** 4/52. **C.** Ch/35 H/31. **D.** 9/14 12/22 16/31 **E.** 3/1 5/9 6/13 7/15 9/14 11/8 14/1 15/1. The habitats of 4 species are unknown. **F.** 1/3 2/18 3/31 4/20 5a/10 5b/7 5c/4. The altitudinal limits of *Hypericum humifusum* L., *H. pseudotenellum* Vandas, and *H. tymphresteum* Boiss. et Spr. are unknown. A majority of species occur in the hill zone. **G.** 2/2 3/3 4/4 5/16 6/27 7/31 8/14 9/1. The flowering periods of 9 species are unknown. **H.** 1/9 2/18 3/9 4/5 4a/1 5/10 6/13 6a/14 6b/10 7/18 7a/3 8/17 8a/15 8b/14 9/4 10/16 10a/1 11/6 12/8 13/7 14/5 15/8 16/5. Sixteen species occur in only 1 district each. **I.** III./5 IV./4 V./1 VI./2 X./8 XI./2 XII./2 XIII./2 XIV./4 XIV.a/3 XVIII./7 XIX./3 XX./23. Thirteen species are Mediterranean in a broad sense, and 23 or 44·2 per cent. are endemic. Many of the latter show Oriental affinities. *Hypericum androsaemum* L. has the discontinuous distribution, in our area: Greece (?), South Bulgaria, and Bosnia. *H. pulchrum* L. is recorded from Greece and Croatia. *H. vesiculosum* Griseb. is known from Greece, the Thessalian Olympus, and the Athos Peninsula.

Elatinaceae. 5 species.

A. *Elatine* 5. **B.** ①/5. **C.** HH/5 Th/5. **D.** 18/5. **E.** 3/5. **F.** 2/4 3/2 4/1. The altitudinal limits of *Elatine triandra* Schk. are unknown. **G.** 5/1 6/2 7/2 8/1 9/1. The flowering periods of *Elatine hexandra* DC., *E. hydropiper* L. sensu Oeder, and *E. triandra* Schk. are unknown. Four of the species are known from only 1 area each. **H.** 1/1 2/1 4a/1 8/3 8a/1 10/2. **I.** VI./2 XII./4. It is not desirable to draw conclusions from the known distribution of the species, because this is probably far from complete.

Frankeniaceae. 2 species.

A. *Frankenia* 2. **B.** 4/1 ①/1. **C.** Ch/1 Th/1. **D.** 9/1 12/1 18/1. **E.** 8/1 9/2. **F.** 1/2. **G.** 4/1 5/1 6/1 7/1. **H.** 1/2 2/2 2a/2 7/2 8a/1 9/2 14/1. **I.** III./1 V./1 XVIII./1. The 2 species are Mediterranean in their distribution in the Balkan Peninsula, but both also occur in the Dobruja.

Tamaricaceae. 8 species.

A. *Tamarix* 8. **B.** ♄/8. **C.** M/7 N/8. **D.** 3/8. **E.** 3/6 6/1 8/1 9/1 14/1 **F.** 1/3 2/7 3/1. **G.** 3/1 4/4 5/6 6/4 7/3 8/1 9/1. **H.** 1/4 2/5 2a/1 3/2 4/1 4a/2 5/3 6/2 6a/3 7/3 8a/2 9/2 13/1 14/2. Two species are each known from only 1 area. **I.** VII./2 X./1 XI./4 XX./1. The species are all Mediterranean. *Tamarix cretica* Bunge is endemic to Crete.

Cistaceae. 29 species.

A. *Helianthemum* 18, *Fumana* 7, *Cistus* 4. **B.** ♄/4 ♃/19 ☉/6. **C.** N/4 Ch/18 H/1 Th/6. **D.** 3/4 9/17 12/8 16/1 18/6. **E.** 5/2 6/10 7/4 8/3 9/16. The habitats of *Fumana aciphylla* Boiss. and *F. laevipes* Spach are unknown. **F.** 1/1 2/16 3/22 4/11 5a/4 5b/5 5c/2. **G.** 3/4 4/14 5/26 6/19 7/10 8/2. **H.** 1/12 2/18 2a/9 3/10 4/4 4a/7 5/17 6/11 6a/10 6b/5 7/11 8/6 8a/9 8b/7 9/3 10/9 10a/1 11/13 12/9 13/12 14/18 15/13 16/12. There is a concentration of species in the south and west. **I.** IV./1 V./7 VI./9 VII./1 VIII./2 X./5 XII./5 XIV.a/1 XV./2 XVIII./8 XIX./1 XX./2. Twenty-four species or 82·7 per cent. are Mediterranean, excluding the one Balkan Peninsular and the two endemic species, although some extend into Central Europe. *Cistus parviflorus* Lam. is known from Crete, Greece, and Thrace.

Violaceae. 58 species.

A. *Viola* 58. **B.** ♃/50 ☉/8. **C.** Ch/16 H/36 Th/8. **D.** 9/10 12/6 14/16 16/27 18/8. **E.** 3/1 5/9 6/6 7/22 8/1 9/16 10/2 11/12 12/2 13/1 14/1. The habitats of 6 species are unknown. **F.** 2/5 3/21 4/25 5a/21 5b/30 5c/14. The altitudinal limits of *Viola brachyphylla* Becker and *V. hirciana* Becker are unknown. **G.** 2/1 3/7 4/15 5/25 6/19 7/21 8/10. The flowering periods of 10 species are unknown. **H.** 1/8 2/13 2a/1 3/9 4/4 5/15 6/23 6a/11 6b/7 7/5 7a/1 8/18 8a/7 8b/17 9/9 10/18 10a/1 11/13 12/14 13/13 14/7 15/12 16/11. Most species occur inland and especially in the mountainous districts of North Macedonia, North Bulgaria, Serbia, Albania, and the Rodope massif. Eighteen species are each known from only 1 area. **I.** III./7 IV./3 V./1 VI./2 VIII./2 X./3 XI./2 XII./7 XIV./1 XIV.a/2 XV./2 XVIII./6 XIX./1 XX./33. The number of endemics is 33 or nearly 57 per cent. It is probable that hybridization and consequent isolation of new morphological groups partly accounts for this. Five species are limited to Crete.

Datiscaceae. 1 species.

A. *Datisca* 1. **B.** ♃/1. **C.** H/1. **D.** 16/1. **E.** 5/1. **F.** 4/1. **G** 7/1. **H.** 1/1. **I.** XI./1 XVIII./1. The one species, *Datisca cannabina* L., is limited to Crete.

Thymelaeaceae. 16 species.

A. *Daphne* 11, *Thymelaea* 3, *Lygia* 2. **B.** ♄/14 ①/2. **C.** N/14 Th/2. **D.** 3/12 4/2 18/2. **E.** 5/4 6/8 7/2 8/1 9/4 11/6 13/2. **F.** 1/1 2/6 3/8 4/11 5a/5 5b/4 5c/2. **G.** 1/1 2/2 3/3 4/7 5/7 6/7 7/8 8/4 9/2 10/1 11/1 12/1. The flowering period of *Lygia pubescens* Boiss, is unknown. **H.** 1/5 2/9 2a/2 3/4 4/2 4a/1 5/7 6/6 6a/6 6b/3 7/5 8/6 8a/1 8b/6 9/1 10/7 11/5 12/6 13/4 14/5 15/5 16/5. **I.** III./2 V./2 VI./2 VIII./1 X./2 XI./2 XII./3 XIV.a/1 XVIII./3 XIX./1 XX./1. Nine species are essentially Mediterranean in their general distribution. *Daphne alpina* L. and *D. cneorum* L. are species whose distribution in our area links on to that in the Alps. *D. collina* Sm. is known from Crete, Greece, and the Athos Peninsula. *D. gnidium* L. is recorded from Greece, Albania, and Dalmatia. The endemic *D. jasminea* S. et S. has several varieties and is known from Greece, South Macedonia, the Athos Peninsula, the Rodope massif, and Hercegovina.

Elaeagnaceae. 2 species.

A. *Elaeagnus* 1, *Hippophae* 1. **B.** ♄/1 ♄/2. **C.** M/2 N/1. **D.** 2/1 4/2. **E.** 8/2 9/1. **F.** 1/1 2/2. **G.** 4/1 5/2 6/1. **H.** 1/1 2/1 2a/1 4a/1 6/1 6a/1 7/2 8/2 9/2 14/1 15/1. **I.** III./2 *Elaeagnus angustifolia* L. is mainly Mediterranean in our area. *Hippophae rhamnoides* L. occurs in Thrace, North Bulgaria, and the Dobruja. Neither species is known from Crete.

Lythraceae. 11 species.

A. *Lythrum* 7, *Peplis* 3, *Ammania* 1. **B.** 4/3 ①/8. **C.** H/3 Th/8. **D.** 16/3 18/8. **E.** 3/10 13/1. **F.** 2/10 3/6 4/1. The altitudinal limits of *Lythrum nummulariaefolium* Loisel. are unknown. **G.** 4/2 5/4 6/4 7/8 8/5 9/1. The flowering periods of *Ammania verticillata* Lam. and *Peplis alternifolia* M.B. are unknown. **H.** 1/2 2/5 2a/2 3/5 4/3 4a/3 5/4 6/2 6a/4 6b/2 7/6 8/4 8a/6 8b/3 9/3 10/6 11/6 12/3 13/1 14/4 15/4 16/3. Three species have been recorded from only 1 area each. **I.** I./2 III./5 IV./1 VI./2 XI./1 XVIII./2. Seven of the species have a very wide general distribution. *Ammania verticillata* Lam. is known from South Bulgaria, Serbia, and Montenegro. *Lythrum nummulariaefolium* Loisel. and *Peplis erecta* Req. are known only from Thrace in our area, and *P. alternifolia* Bieb. only from South Bulgaria.

Punicaceae. 1 species.

A. *Punica* 1. **B.** ♄/1. **C.** M/1. **D.** 2/1. **E.** 6/1. **F.** 2/1 3/1. **G.** 5/1 6/1. **H.** 1/1 2/1 3/1 5/1 6/1 6a/1 7/1 7a/1 11/1 13/1 14/1 16/1. **I.** V./1 XVIII./1. *Punica granatum* L. is widely cultivated and often occurs as an escape from or relict of cultivation.

Myrtaceae. 1 species.

A. *Myrtus* 1. **B.** ħ/1 ħ/1. **C.** M/1. **D.** 1/1 3/1. **E.** 6/1. **F.** 2/1 3/1. **G.** 6/1 7/1 8/1 9/1. **H.** 1/1 2/1 2a/1 3/1 4/1 4a/1 5/1 7/1 7a/1 11/1 13/1 14/1 15/1 16/1. **I.** V./1. *Myrtus communis* L. is decidedly Mediterranean in its distribution, both within and without the Balkan Peninsula. It has a morphologically well-marked variety with narrow leaves (var. *tarentina* L.), which I have collected in South Dalmatia growing with the usual variety.

Oenotheraceae. 22 species.

A. *Epilobium* 17, *Circaea* 3, *Ludvigia* 1, *Trapa* 1. **B.** ɣ/22. **C.** Ch/2 H/17 G/3 HH/2. **D.** 9/2 12/1 16/17 17/3 19/1. **E.** 2/1 3/12 5/7 6/4 7/2 9/2 10/1. **F.** 2/8 3/13 4/14 5a/9 5b/9. **G.** 6/4 7/20 8/18 9/7. The flowering period of *Epilobium alpinum* L. is unknown. **H.** 1/3 2/12 2a/2 3/12 4/6 4a/2 5/11 6/12 6a/10 6b/5 7/8 7a/1 8/16 8a/6 8b/14 9/7 10/16 10a/2 11/16 12/15 13/15 14/8 15/17 16/10. On the whole there is a concentration of species in the northern districts. One species is known from 1 area only. **I.** I./1 I.a/1 III./10 V./1 VI./2 VIII./1 XII./7 XIV.a/3 XV./2 XVIII./4. Twelve species have a very wide general distribution and only 4 a Mediterranean one. Only 3 species are known from Crete and none from the Cyclades. *Trapa natans* L. is recorded for North and South Macedonia, Thrace, North and South Bulgaria, the Dobruja, Serbia, Montenegro, Dalmatia, and Croatia.

Hippuridaceae. 3 species.

A. *Myriophyllum* 2, *Hippuris* 1. **B.** ɣ/3. **C.** HH/3. **D.** 19/3. **E.** 2/3 3/1. **F.** 2/3 3/3 4/2. **G.** 6/3 7/3 8/3. **H.** 1/1 2/2 3/2 4/1 4a/1 5/3 6/2 6a/2 7/2 8/3 8a/1 9/2 10/3 11/3 12/1 13/1 14/2 15/2 16/3. **I.** I./1 III./2. *Hippuris vulgaris* L. appears to have a somewhat discontinuous distribution in Corfu, Albania, North Bulgaria, Serbia, Montenegro, and Istria.

Cynomoriaceae. 1 species.

A. *Cynomorium* 1. **B.** ɣ/1. **C.** G/1. **D.** 17/1. 20/1 **E.** 6/1 9/1. **F.** unknown. **G.** 3/1 4/1 5/1 6/1. **H.** 1/1. **I.** III./1. *Cynomorium coccineum* L. is limited to Crete in our area.

Araliaceae. 2 species.

A. *Hedera* 2. **B.** ħ/2. **C.** MM/1 M/2. **D.** 5/1. **E.** 5/1 6/1 9/1 11/2. **F.** 3/2 4/1. **G.** 10/2 11/2. **H.** 1/1 2/2 3/2 4/1 5/1 6/1 6a/1 6b/1 7/2 7a/1 8/1 8b/1 9/1 10/1 11/1 12/1 13/1 14/1 15/1 16/1. **I.** III./1 VIII./1. *Hedera helix* L. occurs in nearly all the major districts and *H. poetarum* Bert. occurs in Greece, Thessaly, and Thrace.

Umbelliferae. 334 species.

A. *Seseli* 30, *Peucedanum* 27, *Bupleurum* 24, *Oenanthe* 17, *Chaerophyllum* 13, *Eryngium* 12, *Freyera* 12, *Pimpinella* 11, *Laserpitium* 10, *Anthriscus* 8, *Carum* 8, *Ferulago* 8, *Heracleum* 8, *Torilis* 8, *Athamanta* 7, *Daucus* 7, *Trinia* 6, *Bunium* 5, *Caucalis* 5, *Smyrnium* 5, *Angelica* 4, *Malabaila* 4, *Orlaya* 4, *Pastinaca* 4, *Scandix* 4, *Apium* 3, *Ferula* 3, *Johrenia* 3, *Meum* 3, *Opopanax* 3, *Sium* 3, *Tordylium* 3, *Ammi* 2, *Astrantia* 2, *Bifora* 2, *Cnidium* 2, *Conium* 2, *Danaa* 2, *Echinophora* 2, *Foeniculum* 2, *Hippomarathrum* 2, *Ligusticum* 2, *Prangos* 2, *Silaus* 2, *Aegopodium* 1, *Aethusa* 1, *Ainsworthia* 1, *Anethum* 1, *Archangelica* 1, *Astrodaucus* 1, *Bonannia* 1, *Cachrys* 1, *Cicuta* 1, *Colladonia* 1, *Conopodium* 1, *Coriandrum* 1, *Crithmum* 1, *Elaeoselinum* 1, *Falcaria* 1, *Hacquetia* 1, *Hladnika* 1, *Hydrocotyle* 1, *Kundmannia* 1, *Lagoecia* 1, *Lecokia* 1, *Levisticum* 1, *Myrrhis* 1, *Petroselinum* 1, *Physocaulis* 1, *Pleurospermum* 1, *Portenschlagia* 1, *Ptychotis* 1, *Ridolfia* 1, *Sanicula* 1, *Scaligera* 1, *Sclerochorton* 1, *Selinum* 1, *Siler* 1, *Sison* 1, *Stefanoffia* 1, *Thapsia* 1, *Turgeniopsis* 1. **B.** ♄/1 ♃/233 ②/35 ①/68. **C.** N/1 Ch/2 H/233 G/18 HH/14 Th/68. **D.** 3/1 7/15 9/2 16/248 17/18 18/68. **E.** 2/2 3/27 5/42 6/64 7/95 8/11 9/98 11/65 13/37 14/16 15/9 16/10. The habitats of 14 species are unknown. **F.** 1/17 2/132 3/196 4/144 5a/59 5b/62 5c/18. The altitudinal limits of 5 species are unknown. **G.** 3/6 4/33 5/82 6/153 7/211 8/134 9/36 10/5 11/1. The flowering periods of 27 species are unknown. **H.** 1/68 2/133 2a/51 3/103 4/51 4a/27 5/93 6/93 6a/95 6b/36 7/98 7a/4 8/128 8a/79 8b/81 9/65 10/127 10a/15 11/125 12/97 13/102 14/128 15/123 16/97. Species of this family are, in numbers, fairly equally distributed among the districts. **I.** I./2 I.a/1 II./1 III./23 IV./15 V./23 VI./29 VII./1 VIII./26 IX./10 X./20 XI./14 XII./55 XIII./13 XIV./18 XIV.a/13 XV./11 XVIII./61 XIX./7 XX./107. Twenty-seven species or 8 per cent. are very widely distributed. 123 or 36·5 per cent. are Mediterranean in a wide sense, but excluding Balkan Peninsular and endemic species. Fifty-five or 16·4 per cent. are Central European in a strict sense, and 107 or 32 per cent. are endemics. The distribution of a number of species is worth special mention. *Anthriscus nemorosa* M.B. occurs in Greece, North and South Bulgaria, Serbia, Montenegro, Dalmatia, and South Croatia. *Cicuta virosa* L. is recorded from Epirus and the Dobruja. *Echinophora tenuifolia* L., of general Oriental distribution, is known from Crete, Greece, the Cyclades, Thessaly, North and South Macedonia, and the Dobruja. There is one record for Bulgaria, but I have not traced the locality. *Elaeoselinum asclepium* L. is known from Greece, Corfu, Albania, and Thrace. *Freyera balcanica* Hal. is known from Greece, North Macedonia, North Bulgaria, and Serbia. *Hydrocotyle vulgaris* L.

occurs in Crete, Greece, and Dalmatia. *Oenanthe marginata* Vis. is only known from the Pindus and Dalmatia. *O. prolifera* L. occurs in Crete and Dalmatia.

Cornaceae. 3 species.

A. *Cornus* 3. **B.** ħ/3. **C.** M/2 N/2. **D.** 4/3. **E.** 5/2 6/3. **F.** 2/3 3/3 4/2. **G.** 3/1 4/1 5/1 6/1. The flowering period of *Cornus australis* C. A. Mey. is unknown. **H.** 2/2 2a/1 3/2 4a/1 5/2 6/1 6a/2 7/3 8/3 8a/1 8b/1 9/2 10/2 10a/1 11/2 12/2 13/2 14/2 15/2 16/2. **I.** IV./1 VI./1 XII./1 XIV./1 XIV.a/1 XVIII./3. *Cornus mas* L. and *C. sanguinea* L. have a wide distribution in the Balkan Peninsula from Greece northwards. *C. australis* C. A. Mey. is known from Thrace and North Bulgaria. No species is recorded from Crete.

Pirolaceae. 7 species.

A. *Pyrola* 6, *Monotropa* 1. **B.** ɥ/7. **C.** Ch/2 H/4 G/1. **D.** 9/2 14/4 17/1 20/1. **E.** 5/7. **F.** 3/1 4/7 5a/7 5b/7. **G.** 5/3 6/5 7/5 8/3. **H.** 2/2 3/3 5/4 6/2 6a/3 6b/1 8/6 8b/5 10/7 11/5 12/5 13/1 15/6 16/2. **I.** II./5 III./1 XII./1 XVIII./1. All the species, except 1, are very wide in their general distribution, and in the Balkan Peninsula they are commonest in the Central European districts. No species is recorded from Crete.

Ericaceae. 20 species.

A. *Rhododendron* 5, *Erica* 4, *Vaccinium* 4, *Arbutus* 2, *Arctostaphylos* 2, *Bruckenthalia* 1, *Calluna* 1, *Loiseleuria* 1. **B.** ħ/2 ħ/19. **C.** MM/2 M/3 N/13 Ch/5. **D.** 1/2 3/13 4/5 9/3. **E.** 3/1 5/5 6/11 7/4 9/3 11/4. **F.** 2/7 3/9 4/4 5a/4 5b/9 5c/6. **G.** 1/2 2/2 3/4 4/5 5/10 6/8 7/6 8/6 9/3 10/2 11/2 12/2. The flowering periods of *Arctostaphylos alpina* Spr. and *Vaccinium arctostaphylos* L. are unknown. **H.** 1/4 2/4 2a/4 3/4 4/4 4a/3 5/7 6/4 6a/6 6b/5 7/6 7a/2 8/6 8a/4 8b/7 10/7 10a/1 11/5 12/5 13/6 14/9 15/10 16/5. **I.** II./7 VI./2 VII./1 X./2 XII./3 XIII./1 XIV./1 XIV.a/2 XV./8 XVIII./4 XIX./1.

The general and local distribution of the species indicates a varied history for the species in our area. *Arbutus andrachne* L., *A. unedo* L., *Erica arborea* L., and *E. verticillata* Forsk. are typical constituents of the Mediterranean macchia, and are widely distributed in this community in the Balkan Peninsula. The species of *Arctostaphylos*, *Rhododendron*, excepting *R. ponticum* L., *Vaccinium*, excepting *V. arctostaphylos* L., and *Loiseleuria procumbens* Desv. occur in the high mountain zones and indicate floristic connexions with the Alps and Carpathians. *Bruckenthalia spiculifolia* Reichb. is also a high mountain species, but in distribution is a Balkan Peninsular type, growing gregariously in scattered localities in North and South Macedonia,

North Bulgaria, the Rodope massif, and Serbia. *Calluna vulgaris* L. occurs, but seldom abundantly, in the north-west of our area, and is also recorded from Thrace and South Bulgaria. The Central European *E. carnea* L. is known from Albania, Serbia, Bosnia, Hercegovina, Dalmatia, South Croatia, and Istria. The western Mediterranean Basin species, *E. multiflora* L., just reaches our area in Dalmatia. *Rhododendron ponticum* L. and *Vaccinium arctostaphylos* L., both known only from South Bulgaria in the Balkan Peninsula, represent the Pontic-Caucasian element.

Primulaceae. 52 species.

A. *Cyclamen* 11, *Primula* 11, *Lysimachia* 8, *Androsace* 6, *Soldanella* 6, *Anagallis* 4, *Asterolinum* 1, *Centunculus* 1, *Coris* 1, *Cortusa* 1, *Hottonia* 1, *Samolus* 1. **B.** 4/43 ①/9. **C.** Ch/7 H/25 G/11 HH/2 Th/9. **D.** 12/7 13/2 14/21 16/5 17/11 18/9. **E.** 2/2 3/7 5/11 6/12 7/14 8/7 9/13 10/7 11/7 12/3 13/3 16/1. The habitats of 4 species are unknown. **F.** 1/2 2/16 3/30 4/24 5a/14 5b/15 5c/7. A majority of species occur in the hill and montane zones, but another maximum is reached in the high mountain zone 2. The altitudinal limits of *Cyclamen pseudograecum* Hildebr. and *Primula glutinosa* Wulf are unknown. **G.** 1/1 2/3 3/7 4/13 5/19 6/25 7/23 8/10 9/8 10/7 11/5 12/1. The flowering periods of 6 species are unknown. **H.** 1/13 2/18 2a/6 3/14 4/6 4a/6 5/22 6/19 6a/18 6b/7 7/16 7a/2 8/24 8a/11 8b/19 9/8 10/24 10a/5 11/17 12/17 13/18 14/16 15/20 16/13. The greatest number of species occurs in North Bulgaria. On the whole there is a greater concentration of species in the more northern areas. Thirteen species occur in only 1 area each. **I.** I./5 III./6 IV./3 V./1 VI./1 VII./1 VIII./2 X./4 XI./1 XII./10 XIV./1 XIV.a/2 XV./6 XVI./1 XVIII./10 XX./12. Eleven species have a very wide general distribution. Ten species are Mediterranean, wholly or partially, excluding the 12 endemics. Ten species are Central European (XII.) and 6 Alpine (XV.) in our sense, but several correctly listed as XII. are, for the Balkan Peninsula, really Alpine in connexion. The North-West African species, *Anagallis platyphylla* Baudo, I found in South Macedonia, but it had probably been introduced with army fodder. *A. tenella* L. occurs in Crete and Corfu. *Coris monspeliensis* L. is known from Greece and Albania, and *Cortusa matthioli* L. from North Bulgaria and the Rodope massif. Most of the species of *Cyclamen* are Mediterranean. *Hottonia palustris* L. is recorded from scattered localities in North Bulgaria, the Dobruja, Serbia, and South Croatia. *Primula farinosa* L., as the var. *exigua* (Vel.) Pax occurs in North Bulgaria and the Rodope massif. The species of *Soldanella* have a discontinuous high mountain distribution and indicate floristic connexions with the Alps and Carpathians.

Plumbaginaceae. 39 species.

A. *Limonium* 19, *Armeria* 10, *Goniolimon* 7, *Acantholimon* 1, *Limoniastrum* 1, *Plumbago* 1. **B.** ♄/1 ♃/37 ☉/1. **C.** Ch/3 H/36 Th/1. **D.** 7/1 9/2 12/1 14/33 16/4 18/1. **E.** 6/1 7/5 8/14 9/12 11/10 13/1 16/1. The habitat of *Armeria vandasii* Hayek is unknown. **F.** 1/23 2/9 3/15 4/9 5a/3 5b/3 5c/3. **G.** 3/1 4/1 5/9 6/21 7/34 8/27 9/10 10/6 11/2. The flowering period of *Armeria dalmatica* Beck is unknown. The maximum number of species are flowering in July. **H.** 1/9 2/18 2a/11 3/5 4/4 4a/2 5/6 6/10 6a/12 6b/5 7/12 7a/1 8/10 8a/8 8b/6 9/8 10/8 11/4 12/1 13/5 14/4 15/3 16/4. The largest number of species occurs in Greece and the next largest in Dalmatia. Ten species are limited to 1 area each and 7 of these are endemics. **I.** III./1 IV./2 VI./6 VII./1 VIII./3 IX./1 X./7 XII./2 XIII./2 XIV.a/1 XV./1 XVIII./3 XIX./1 XX./13. The Mediterranean species total 18, excluding Balkan Peninsular and endemic species. The last number 13 or 33 per cent. *Goniolimon tataricum* Boiss., here listed as a 'very wide' (III.), is, for the Balkan Peninsula, Dacian (XIII.) in its connexions.

Ebenaceae. 1 species.

A. *Diospyros* 1. **B.** ♄/1. **C.** MM/1. **D.** 2/1 4/1. **E.** 5/1 6/1. **F.** 2/1 3/1. **G.** 5/1 6/1 7/1 8/1. **H.** 2/1 7/1 14/1 15/1. **I.** XI./1. *Diospyros lotus* L. is known from Greece, Thrace, Dalmatia, and South Croatia.

Styracaceae. 1 species.

A. *Styrax* 1. **B.** ♄/1 ♄/1. **C.** M/1 **D.** 2/1 4/1. **E.** 6/1. **F.** 2/1 3/1 4/1. **G.** 4/1 5/1. **H.** 1/1 2/1 2a/1 7/1 14/1. **I.** VI./1. The Mediterranean Basin species, *Styrax officinalis* L., is found in Crete, Greece, the Cyclades, Thrace, and Dalmatia, thus typically limiting itself to the Mediterranean domain.

Oleaceae. 15 species.

A. *Fraxinus* 5, *Jasminum* 3, *Phillyrea* 3, *Forsythia* 1, *Ligustrum* 1, *Olea* 1, *Syringa* 1. **B.** ♄/6 ♄/13. **C.** MM/5 M/11 N/7. **D.** 1/1 2/4 3/6 4/7 7/1 **E.** 5/9 6/12 9/4 11/1. **F.** 2/11 3/15 4/7. **G.** 3/5 4/10 5/9 6/6 7/1. **H.** 1/2 2/7 2a/1 3/6 4/7 4a/2 5/9 6/7 6a/7 6b/2 7/8 7a/1 8/7 8a/5 8b/5 9/6 10/4 10a/4 11/8 12/5 13/16 14/7 15/9 16/8. Only *Olea europaea* L. and *Phillyrea media* L. are known with certainty from Crete. **I.** IV./2 V./3 VI./3 VII./2 XI./2 XIV./1 XIV.a/3 XVIII./6 XIX./1 XX./2. Ten species are essentially or partially Mediterranean, including *Olea europaea* L. and *Phillyrea media* L., the only species known from Crete. The relict type, *Forsythia europaea* Degen et Baldacci occurs in Albania and the Sandjak of Novi Pazar. *Fraxinus pallisae* Wilmott is an interesting and distinct species of ash endemic to North and South Bulgaria and the Dobruja. *Jasminum officinale* L. is recorded from South Macedonia, Thrace, and South Croatia.

Gentianaceae. 41 species.

A. *Gentiana* 26, *Centaurium* 8, *Blackstonia* 2, *Swertia* 2, *Limnanthemum* 1, *Menyanthes* 1, *Microcala* 1. **B.** 4/19 ②/5 ①/20. **C.** Ch/1 H/20 G/1 HH/2 Th/20. **D.** 12/1 14/8 16/17 17/1 18/20 19/2. **E.** 2/1 3/3 5/4 6/5 7/32 8/1 9/9. The habitats of *Gentiana pontica* Solt. and *G. rhaetica* A. et J. Kern. are unknown. **F.** 1/3 2/12 3/19 4/16 5a/14 5b/16 5c/11. The altitudinal limits of *Gentiana obtusifolia* Willd., *G. pontica* Solt., and *G. rhaetica* A. et J. Kern. are unknown. **G.** 4/3 5/8 6/15 7/26 8/20 9/10 10/3. The flowering periods of 6 species are unknown. **H.** 1/6 2/9 2a/4 3/10 4/5 4a/6 5/18 6/16 6a/7 6b/4 7/9 8/21 8a/5 8b/16 9/6 10/21 10a/2 11/27 12/20 13/14 14/16 15/19 16/15. There is a concentration of species in the central and mountainous districts. **I.** II./3 III./4 IV./4 V./1 VI./4 VIII./3 X./2 XII./10 XIV./2 XIV.a/4 XV./9 XIX./5 XX./4.

The distribution of each of the 26 species of *Gentiana* is of considerable interest, and may be mentioned in some detail as an example of the data used in this portion of my work.

G. anisodonta Borb. (*G. calycina* Wettst.) has a general distribution in the eastern and south-eastern Alps and extends to the Abruzzi. In the Balkan Peninsula it is known from Mt. Maggiore and the Predilstrasse in Istria and from several mountainous districts in South Croatia. As the subsp. *albanica* Jávorka it is recorded from Mt. Škelsen near Djakovo in northern Albania at 2,100 m.

G. asclepiadea L. has a wide distribution in the Balkan Peninsula from northern Greece (Mt. Oeta) and the Thessalian Olympus, through Albania, North and South Macedonia, North Bulgaria, the Rodope massif, Serbia, Montenegro, Bosnia, Hercegovina, Dalmatia, South Croatia, to Istria. Its general distribution is from Central Europe to the Caucasus and Pontic districts.

G. bulgarica is known from Albania, North Macedonia, North Bulgaria, the Rodope massif, Serbia, the Bithynian Olympus, and Transylvania. It is thus a typical Balkan Peninsular species, just extending over our borders in the north and south-east.

G. campestris L. is essentially Central European and is recorded from Montenegro, but I have seen no specimens and am somewhat doubtful of the identification.

G. carpatica Wettst. is essentially east Central European with two isolated distributional areas in the Balkan Peninsula, namely, one in North Bulgaria and the Rodope massif and the other in Montenegro and Bosnia. The former is certainly connected with the southern Carpathian area, a type of distribution met with in a number of species, but the latter is puzzling and suggests an independent origin.

G. ciliata L., Central European, Pontic, and Caucasian, extends from Istria and South Croatia to Montenegro, Serbia, North Bulgaria, and the Rodope massif in our area.

G. clusii Per. et Song., Central European in general distribution and Alpine in its Balkan Peninsular relationships, is known in our area from Serbia, Montenegro, Bosnia, Dalmatia, and South Croatia.

G. crispata Vis. is endemic to Albania, Montenegro, Bosnia, Hercegovina, Dalmatia, and South Croatia.

G. cruciata L. has a very wide (III.) general distribution and in the Balkan Peninsula is known from Thessaly, Albania, North and South Macedonia, North Bulgaria, the Rodope massif, the Dobruja, Serbia, the Sandjak of Novi Pazar, Montenegro, Bosnia, Hercegovina, Dalmatia, South Croatia, and Istria.

G. frigida Haenke., a Central European (especially Carpathian) mountain species, is known in our area only from the Rodope massif.

G. germanica L. a general European and Caucasian species is recorded from Serbia, Montenegro, Bosnia, and South Croatia.

G. kochiana Per. et Song. is known from Bulgaria, Serbia, Montenegro, Bosnia, and Hercegovina. Its general distribution is Central European.

G. lutea L. is probably represented in the Balkan Peninsula only by the subsp. *symphyandra* Murbeck, which occurs in Thessaly, North Macedonia, North Bulgaria, the Rodope massif, Serbia, Montenegro, Bosnia, Hercegovina, Dalmatia, South Croatia, and Istria, and extends just beyond our boundaries into Venetia. Occasionally it shows morphological characters linking it to the commoner variety or subspecies which has a wide distribution in Central Europe, and, according to Beck, also occurs again in Mt. Tmolus in Asia Minor.

G. lutescens Vel. is found in North Macedonia, North Bulgaria, the Rodope massif, Serbia, Montenegro, and Bosnia. North of our area it occurs in Hungary (sensu ann. 1914), Galicia, and lower Austria.

G. nivalis L. has the widest general distribution (II.) of all our species of gentians. In the Balkan Peninsula it is known from North Macedonia, North Bulgaria, the Rodope massif, Serbia, Bosnia, Dalmatia, and South Croatia.

G. nopcsae Jávorka is endemic to northern Albania.

G. obtusifolia Willd. is a Central European, Caucasian, and Pontic species extending to the Bithynian Olympus and doubtfully recorded from Montenegro.

G. pannonica Scop. is an eastern Alpine species which occurs in South Croatia.

G. pneumonanthe L has a very wide general distribution (III.) and

is known from North Macedonia, North Bulgaria, the Rodope massif, Montenegro, Bosnia, Hercegovina, and South Croatia in our area.

G. pontica Soltok. occurs in the mountains of Asia Minor and thence to the Caucasus and north Persia. In the west it extends to the Šipka Balkan. Its taxonomic relationship is with *G. tergestina*.

G. punctata L. is a Central European species known from Albania, North Macedonia, North Bulgaria, the Rodope massif, Serbia, Montenegro, Bosnia, and Istria in our area.

G. pyrenaica L., a species found in the Pyrenees, Carpathians, and Pontic mountains east to the Caucasus, is known only from the Rodope massif in our area.

G. rhaetica A. et J. Kern., a microspecies of the *G. germanica* group described from the southern Tyrol is recorded from Bosnia.

G. tergestina Beck is a Balkan Peninsular species extending into Carinthia and Carniola. It is known from Albania, the Rodope massif, Serbia, Montenegro, Bosnia, Hercegovina, Dalmatia, South Croatia, and Istria. The species is related to *G. angulosa* Bieb. of the Caucasus, Central Asia, and the northern Orient.

G. utriculosa L. of Central and South Europe is known from Albania, North Macedonia, North Bulgaria, the Rodope massif, Serbia, Montenegro, Bosnia, Hercegovina, Dalmatia, South Croatia, and Istria.

G. verna L., of very wide general distribution (III.), is known from Thessaly, Epirus, Albania, North Macedonia, North Bulgaria, the Rodope massif, Serbia, Montenegro, Bosnia, and Hercegovina.

The species enumerated above can be grouped as follows :

1. Species having a centre of distribution in the Alps and apparently extending thence into the Balkan Peninsula. *G. anisodonta* (south to Albania), *G. campestris* (only from Montenegro?), *G. clusii* (south to Serbia and Montenegro), *G. kochiana* (south to Montenegro and east to North Bulgaria), *G. nivalis* (south to North Macedonia and the Rodope massif), *G. pannonica* (Croatia), *G. utriculosa* (south to Albania and the Rodope massif).

2. Species having a centre of distribution in the Carpathians and apparently extending thence into the Balkan Peninsula. *G. carpatica* (south to the Rodope massif and west to Montenegro and Bosnia), *G. frigida* (Rodope massif).

3. Endemic or Balkan Peninsular species. *G. bulgarica* (north to Transylvania and south-east to the Bithynian Olympus), *G. crispata* (a morphologically very distinct species with a compact distribution), *G. lutea* subsp. *symphyandra* (vicarious with the northern subsp. *lutea*), *G. lutescens* (north to Lower Austria), *G. nopcsae* (a small species of the section *Pneumonanthe*), G. *tergestina* (a distinct species of the *Cyclostigma* section).

4. Species of very wide, wide, or rather wide general distribution. *G. asclepiadea* (goes farthest south of all species in our area), *G. ciliata* (has a broad connexion from the Balkan Peninsula to the countries to the north and especially north-west), *G. cruciata* (also has a broad connexion with the north), *G. germanica* (appears to have a north-western distribution in our area), *G. pneumonanthe* (south to North Macedonia and the Rodope massif), *G. punctata* (south to North Macedonia and the Rodope massif, has both Alpine and Carpathian connexions), *G. verna* (a broad connexion with the north).

5. Species apparently isolated in the Balkan Peninsula, but in part possibly wrongly recorded. *G. obtusifolia* (Central Europe &c., and ? Montenegro), *G. pontica* (Pontic mountains, Caucasus, and ? North Bulgaria), *G. rhaetica* (Alps and ? Bosnia).

Several interesting facts of distribution remain to be noted. No species of *Gentiana* occurs in Crete, in the Peloponnese, in Corfu, or in Thrace. The most southern records in our area are: *G. asclepiadea* from Mt. Oeta and the Thessalian Olympus; *G. lutea* subsp. *symphyandra* from Mt. Oeta; *G. verna* from Epirus and the Thessalian Olympus.

There is practically no sure evidence for any direct connexion with Asia Minor or the Caucasus, and it is doubtful if, for this genus, the Balkan Peninsula has acted as a bridge between the rest of Europe and western Asia. A majority of the species appear to have reached our area from the north, and especially from the Alps and Carpathians. Some of the species have penetrated south to Albania and the Rodope massif, while others have only reached South Croatia, Bosnia, or Montenegro. The immigrants from the Carpathians are particularly established in the Rodope massif, though the connexion from the western mountains (of Bosnia, Montenegro, and Albania) to this needs investigation by further field collecting, especially in the mountains of North Macedonia. The times of the immigrations from the north are difficult to determine. The Alps and Carpathians were linked to the Peninsula long before the Sarmatian and Pontic seas dried up, and probably some species, now partly of lower altitudes, reached the Peninsula by these routes as the mountains were forming. Such were possibly: *G. asclepiadea*, *G. carpatica*, *G. cruciata*, *G. pneumonanthe*, and *G. utriculosa*. Others, however, would appear either to have extended their distribution to the Balkan Peninsula during the Ice Age or to have become exterminated in all or most areas outside that refuge at this time. On the return of a milder climate to the Alps and Carpathians these possibly re-extended again farther north, at least as reinforcements to any survivals which had continued to exist in the eastern and southern peripheral districts of the Alps. *Gentiana*

lutea subsp. *lutea* very possibly represents such a survival outside and the subsp. *symphyandra* a survival within the Balkan Peninsula. *G. crispata* is probably an old species or type, which has survived only within the Peninsula, and has not since extended beyond its northern limits. *G. tergestina* may also be a survival, which has, however, spread northwards. *G. pyrenaica* is the most interesting of the isolated species, but its general distribution is also exceptionally discontinuous. It must be regarded as an Ice Age relict, for it is now limited in our area to the highest zones of the Rila, Rodope, and Pirin. Within the Peninsula a few microspecies have arisen, as *G. bulgarica*, *G. lutescens*, and *G. nopcsae*.

Few comments are necessary regarding the other genera. *Centaurium* is mainly Mediterranean. *Menyanthes* is probably Central European relative to our area, and the two species of *Swertia* are probably linked in distribution to the Carpathians, though it is noteworthy that *S. perennis* is recorded from Montenegro, and this may possibly represent a past Alpine connexion.

Apocynaceae. 7 species.

A. *Vinca* 4, *Apocynum* 1, *Nerium* 1, *Rhazya* 1. **B.** ħ/2 ɥ/5. **C.** N/2 Ch/5 H/1. **D.** 9/3 12/4 16/1. **E.** 3/1 5/1 6/4 7/1 8/1 9/2. **F.** 2/5 3/5 4/2. **G.** 2/2 3/3 4/5 5/4 6/2 7/1 8/2. **H.** 1/2 2/2 2a/1 3/2 4a/1 5/1 6/3 6a/4 7/5 8/4 8a/2 9/2 10/2 11/1 12/1 14/2 15/3 16/2. **I.** III./1 V./1 VI./1 X./2 XII./1 XIII./1 XIV./1 XVIII./3 XX./1.

Apocynum venetum L. has an exceptionally discontinuous distribution in our area, occurring in Thrace, South Bulgaria, the Dobruja, and Istria. The last locality is an extension from the sea-board of Venetia, where the species is almost certainly an established alien. The other records may represent independent immigrations; one from the south, via Asia Minor into Thrace, the other from the north-east from South Russia into the Dobruja. The species is known from Asia Minor and South Russia and has a wide distribution in the Orient, to North India, Central Asia, and China. *Rhazya orientalis* A. DC., an eastern Mediterranean Basin species, is now known from Thrace. *Vinca major* L. occurs in Crete, Corfu, Albania, North and South Macedonia, North Bulgaria, Serbia, South Croatia, and Istria.

Asclepiadaceae. 13 species.

A. *Vincetoxicum* 9, *Cynanchum* 1, *Gomphocarpus* 1, *Marsdenia* 1, *Periploca* 1. **B.** ħ/3 ɥ/11. **C.** M/2 N/2 H/10. **D.** 4/1 5/2 9/1 16/10. **E.** 3/1 5/2 6/6 7/1 9/5 16/1. **F.** 1/1 2/7 3/10 4/5 5a/3 5b/2. **G.** 4/1 5/4 6/11 7/8 8/3. **H.** 1/4 2/7 2a/3 3/5 4/1 4a/2 5/7 6/5 6a/7 6b/5 7/5 7a/1 8/4 8a/3 8b/5 9/4 10/1 11/6 13/4 14/8 15/3 16/4. Two species

(1 endemic) are limited to one area each. **I.** III./1 VI./1 VIII./1 X./2 XI./3 XII./1 XIV.a/1 XVIII./3 XIX./1 XX./5. Eight species, excluding the Balkan Peninsular and endemics, are Mediterranean. It is somewhat strange that *Cynanchum acutum* L. does not appear to occur in Crete. The five endemics are all species of *Vincetoxicum*.

Convolvulaceae. 34 species.

A. *Convolvulus* 19, *Cuscuta* 10, *Calystegia* 3, *Cressa* 1, *Ipomoea* 1. **B.** ♄/1 ♃/20 ①/13. **C.** Ch/10 H/11 Th/13. **D.** 9/4 12/6 15/7 16/4 18/13 20/10. **E.** 3/4 5/2 6/8 7/13 8/3 9/9 11/5 13/2. **F.** 1/6 2/18 3/22 4/10 5a/2 5b/1 5c/1. **G.** 3/1 4/6 5/18 6/21 7/22 8/13. The flowering period of *Cuscuta trifolii* Babington et Gibs. is unknown. **H.** 1/15 2/25 2a/13 3/12 4/7 4a/8 5/9 6/9 6a/11 6b/4 7/16 7a/1 8/9 8a/9 8b/8 9/11 10/11 11/9 12/5 13/7 14/12 15/9 16/8. Most species occur in Greece. Eleven species occur each in only one area. **I.** I./3 III./6 V./3 VI./5 VII./2 VIII./2 X./2 XI./4 XII./2 XIV./1 XIV.a/3 XVII./1 XVIII./4 XX./3. Eighteen species or more than 50 per cent., excluding the endemics, are essentially Mediterranean in their general distribution. *Convolvulus lineatus* L. is known from Greece, Albania, North Macedonia, and the Dobruja. *C. persicus* L. occurs on the sea coasts of Thrace and the Dobruja. The western Mediterranean *C. tricolor* L. has a discontinuous distribution in Greece, South Macedonia, Thrace, and Dalmatia. *Ipomoea sagittata* Poir. occurs in Greece.

Polemoniaceae. 1 species.

A. *Polemonium* 1. **B.** ♃/1. **C.** H/1. **D.** 16/1. **E.** 7/1 9/1. **F.** 4/1. **G.** 6/1 7/1. **H.** 3a/1 10/1 12/1. **I.** III./1. The single species, *Polemonium caeruleum* L., has a discontinuous distribution in our area.

Borraginaceae. 155 species.

A. *Anchusa* 20, *Myosotis* 19, *Onosma* 17, *Alkanna* 13, *Echium* 10, *Lithospermum* 9, *Pulmonaria* 8, *Symphytum* 8, *Heliotropium* 7, *Cerinthe* 6, *Cynoglossum* 6, *Nonnea* 6, *Lappula* 4, *Solenanthus* 4, *Lycopsis* 3, *Moltkia* 2, *Omphalodes* 2, *Rindera* 2, *Trachystemon* 2, *Asperugo* 1, *Borrago* 1, *Halacsya* 1, *Macrotomia* 1, *Mattiastrum* 1, *Rochelia* 1, *Tournefortia* 1. **B.** ♄/2 ♃/84 ②/32 ①/46. **C.** Ch/15 H/93 G/4 HH/2 Th/46. **D.** 3/2 9/15 16/95 17/4 18/46. **E.** 3/6 5/17 6/17 7/34 8/21 9/61 10/1 11/30 13/20 14/6 16/15. The habitats of 4 species are unknown. **F.** 1/20 2/68 3/101 4/64 5a/25 5b/13 5c/6. The altitudinal limits of *Myosotis versicolor* Sm. and *Rochelia disperma* Stapf are unknown. **G.** 2/6 3/30 4/65 5/101 6/87 7/60 8/21 9/7 10/2 11/2. The flowering periods of 10 species are unknown. **H.** 1/37 2/78 2a/34 3/43 4/27 4a/23 5/46 6/56 6a/61 6b/8 7/62 7a/3 8/63 8a/55 8b/46 9/38 10/45

10a/3 11/46 12/38 13/36 14/45 15/34 16/34. Thirty species occur each in only 1 area. **I.** II./2 III./19 IV./2 V./18 VI./7 VIII./5 IX./3 X./21 XI./4 XII./16 XIII./8 XIV./7 XIV.a/9 XV./3 XVIII./23 XIX./9 XX./47. Twenty-one species, or 13·5 per cent. are very wide in their general distribution. Fifty-eight species or 37·4 per cent. are Mediterranean, excluding Balkan Peninsular and endemic species. Forty-seven or 30·3 per cent. are endemic. Eleven of the 13 species of *Alkanna* are endemic. *A. sieberi* DC. is known only from Crete and Thrace. Both *Anchusa* and *Onosma* contain a number of microspecies whose exact taxonomic value can only be ascertained by more field observations, collecting, and controlled breeding. *Halacsya sendtneri* Dörfler is endemic to Albania, North Macedonia, Serbia, and Bosnia. *Rindera graeca* Boiss. et Heldr. is known from Greece and Epirus and *R. umbellata* Bunge from North Bulgaria, the Dobruja, and Serbia. *Rochelia disperma* Stapf is recorded from Thessaly and the Dobruja. The species of *Solenanthus* have a vicarious distribution in our area. *S. albanicus* Degen et Baldacci occurs in Epirus, *S. apenninus* Hohen. in Albania, *S. scardicus* Bornm. in North Macedonia, and *S. stamineus* Wettst. in Greece. *Tournefortia sibirica* L. occurs in Thrace, North Bulgaria, and the Dobruja.

Verbenaceae. 5 species.

A. *Verbena* 3, *Lippia* 1, *Vitex* 1. **B.** ♄/1 4/3 ①/1. **C.** M/1 N/1 Ch/1 H/2 Th/1. **D.** 4/1 9/1 12/1 16/2 18/1. **E.** 3/2 6/1 7/1 8/2 16/2. **F.** 1/1 2/5 3/4 4/1 5a/1 5b/1. **G.** 5/1 6/4 7/4 8/3 9/2 10/1. The flowering period of *Verbena rumelica* Vel. is unknown. **H.** 1/4 2/4 2a/2 3/3 4/2 4a/3 5/3 6/1 6a/2 6b/1 7/4 7a/1 8/1 8a/2 8b/2 9/1 10/1 10a/1 11/2 12/1 13/2 14/3 15/2 16/2. **I.** I./2 V./1 VI./1 XVIII./2 XX./1. *Lippia nodiflora* L. and *Verbena officinalis* L. have a very wide general distribution. *V. supina* L. and *Vitex agnus-castus* L. are typically Mediterranean in their distribution both within and without the Balkan Peninsula. It is very doubtful if *Verbena rumelica* Vel. is more than a variety or form of *V. officinalis* L.

Labiatae. 371 species.

A. *Thymus* 78, *Stachys* 52, *Salvia* 31, *Teucrium* 23, *Lamium* 20, *Calamintha* 19, *Micromeria* 16, *Nepeta* 14, *Satureia* 14, *Sideritis* 13, *Scutellaria* 12, *Ajuga* 10, *Mentha* 9, *Marrubium* 7, *Phlomis* 7, *Ballota* 6, *Amaracus* 5, *Galeopsis* 5, *Betonica* 4, *Lavandula* 3, *Majorana* 3, *Prunella* 3, *Leonurus* 2, *Lycopus* 2, *Origanum* 2, *Coridothymus* 1, *Dracocephalum* 1, *Glechoma* 1, *Hyssopus* 1, *Melissa* 1, *Melittis* 1, *Molucella* 1, *Prasium* 1, *Rosmarinus* 1, *Thymbra* 1, *Zizyphora* 1. **B.** ♄/19 4/319 ②/1 ①/35. **C.** N/10 Ch/204 H/151 G/1 HH/4 Th/35 **D.** 3/8 4/6 7/6 9/122 12/97 16/152 17/1 18/35. **E.** 3/15 5/39 6/68

Stachys italica Mill.

The *Labiatae* are amongst the commonest summer-flowering species in the Balkan Peninsula flora. *Stachys italica* Mill., sensu lato, is represented by a considerable number of varieties, of which that figured is from seed collected on Mt. Sergi, near Dubrovnik (Ragusa).

Digitalis lanata Ehrh.

This species has a wide distribution through the central parts of the Balkan Peninsula, and especially occurs in shiblyak and pseudomacchie. The specimen figured was grown from seed collected near Bačkova in the northern Rodopes.

7/63 8/6 9/169 11/83 13/25 14/3 15/3 16/17. The habitats of 30 species are unknown. **F.** 1/3 2/166 3/248 4/176 5a/67 5b/66 5c/22. The altitudinal limits of 8 species are unknown. **G.** 1/1 2/5 3/26 4/66 5/140 6/208 7/225 8/131 9/35 10/14 11/4 12/1. The flowering periods of 44 species are unknown. **H.** 1/76 2/162 2a/52 3/114 4/73 4a/48 5/106 6/117 6a/122 6b/36 7/115 7a/16 8/130 8a/104 8b/103 9/65 10/125 10a/9 11/109 12/79 13/89 14/116 15/91 16/86. Most species are known from Greece, but the family is well represented in all the districts. **I.** I./2 III./36 IV./14 V./14 VI./23 VII./2 VIII./21 IX./9 X./36 XI./14 XII./31 XIII./12 XIV./14 XIV.a/21 XV./3 XVI./3 XVIII./50 XIX./5 XX./152. Thirty-eight species or 10 per cent. have a very wide general distribution. One hundred and nineteen or nearly 32 per cent., excluding the Balkan Peninsular and endemic species, are Mediterranean. One hundred and fifty-two or 40·9 per cent. are endemics, and a majority of these are Mediterranean in distribution and affinity. The 5 species of *Amaracus* are all endemic to Crete, Greece, and the Cyclades, 3 being limited to Greece. *Mentha piperita* L. is recorded from South Bulgaria and Istria. *Micromeria microphylla* Benth. is known from Crete and Dalmatia. *Scutellaria rupestris* Boiss. et Heldr. is recorded from Greece, Thrace, and the Rodope massif. The known distribution of *Stachys maritima* L. in our area is discontinuous, namely, Greece, North Bulgaria, the Dobruja, and Dalmatia. The genus *Thymus* is represented by a host of microspecies whose taxonomy is not yet in a satisfactory condition. They mostly belong to the *Serpyllum* section. It is probable that hybridization occurs freely and detailed field studies and breeding experiments are more likely to yield stable conclusions than mere herbarium studies such as have been attempted hitherto.

Solanaceae. 18 species.

A. *Hyoscyamus* 4, *Lycium* 3, *Solanum* 3, *Datura* 2, *Mandragora* 2, *Atropa* 1, *Physalis* 1, *Scopolia* 1, *Withania* 1. **B.** ♄/4 ♃/9 ②/2 ①/6. **C.** N/4 Ch/3 H/8 G/1 Th/6. **D.** 4/4 5/1 7/2 9/3 16/8 17/1 18/6. **E.** 5/3 6/3 7/3 9/6 11/1 13/3 16/7. **F.** 1/1 2/14 3/10 4/6. **G.** 1/2 2/5 3/6 4/10 5/14 6/13 7/11 8/6 9/5 10/3 11/1 12/1. **H.** 1/7 2/12 2a/6 3/8 4/6 4a/5 5/8 6/5 6a/8 6b/4 7/9 8/7 8a/5 8b/6 9/5 10/7 10a/1 11/7 12/6 13/8 14/9 15/8 16/9. Three species are only known from one area each. **I.** I./2 I.a/1 III./3 V./5 VI./1 VIII./1 IX./1 XI./3 XII./1 XIV./1 XVIII./3. Eleven species are essentially Mediterranean in general distribution. *Hyoscyamus reticulatus* L. is known from Crete and Thrace. The Oriental *Mandragora mas* Garsault (sensu Vierh.) occurs in Hercegovina and Dalmatia. The habitat and altitudinal limits of *Lycium arabicum* Schweinf. are unknown.

Scrophulariaceae. 311 species.

A. *Verbascum* 81, *Veronica* 52, *Alectorolophus* 31, *Euphrasia* 19, *Pedicularis* 19, *Scrophularia* 19, *Linaria* 17, *Melampyrum* 17, *Celsia* 11, *Digitalis* 7, *Odontites* 6, *Antirrhinum* 5, *Elatinoides* 5, *Chaenorrhinum* 4, *Cymbalaria* 4, *Parentucellia* 2, *Wulfenia* 2, *Bartsia* 1, *Bellardia* 1, *Gratiola* 1, *Limosella* 1, *Lindernia* 1, *Orthantha* 1, *Rhinanthus* 1, *Sibthorpia* 1, *Siphonostegia* 1, *Tozzia* 1. **B.** ♄/1 ↯/110 ②/89 ①/111. **C.** Ch/40 H/157 G/4 HH/5 Th/111. **D.** 9/28 12/15 14/9 16/156 17/4 18/111 20/93. The 93 parasites are half-parasites of the tribe *Rhinantheae*. **E.** 3/22 5/35 6/35 7/105 8/14 9/80 10/3 11/43 12/2 13/30 14/8 15/1 16/6. The habitats of 32 species are unknown. **F.** 1/9 2/99 3/175 4/144 5a/69 5b/75 5c/34. The altitudinal limits of 9 species are unknown. **G.** 1/2 2/12 3/23 4/50 5/99 6/162 7/188 8/120 9/41 10/6 11/1 12/1. The flowering periods of 19 species are unknown. **H.** 1/41 2/96 2a/33 3/81 4/41 4a/32 5/89 6/95 6a/85 6b/26 7/71 7a/6 8/116 8a/73 8b/95 9/43 10/107 10a/11 11/115 12/100 13/89 14/79 15/93 16/82. Ninety-two species are each known from one area only. **I.** I./3 II./2 III./34 IV./10 V./18 VI./15 VIII./15 IX./7 X./16 XI./5 XII./52 XIII./5 XIV./18 XIV.a/10 XV./17 XVIII./38 XIX./11 XX./126. The distribution of *Sibthorpia europaea* L. has not been included in the above. The species with a very wide distribution (I.–III.) total 39, the Mediterranean, excluding Balkan Peninsular and endemic species, total 76 or 24·5 per cent. The Central European in our limited sense number 52 or 16·8 per cent.; endemics number 126 or 40·7 per cent. The genus *Alectorolophus* is particularly well developed in Montenegro, Bosnia, and Hercegovina, where many microspecies occur. *Antirrhinum tortuosum* Bosc. et Lam. is known from Thrace and Dalmatia. The western European *Sibthorpia europaea* L. occurs in our area, so far as is known, only in Crete. *Siphonostegia syriaca* Boiss. et Reut. is known from Thrace. The genus *Verbascum* is richly developed, containing 81 species of which 56 or 69·1 per cent. are endemic. While some of these endemics are taxonomically very distinct species, others are morphologically microspecies and it is very probable that hybridization and subsequent segregation and complete or partial isolation account for some of them. Moreover, field observations have led me to suggest that the destruction of high forest, which I have proved for many parts of the Balkan Peninsula, has led to much stony, dry, relatively bare, or brushwood covered ground, especially hill-slopes, being available for the spread and development of the genus. The genus *Veronica* contains 52 species of which 15 or 28·8 per cent. are endemic. *Wulfenia baldaccii* Degen is endemic to Albania and *W. carinthiaca* Jacq. is known from Albania and Montenegro.

Orobanchaceae. 41 species.

A. *Orobanche* 38, *Lathraea* 2, *Phelipaea* 1. **B.** 4/37 ①/4. **C.** G/37 Th/4. **D.** 17/37 18/4 20/41. **E.** 5/4 6/7 7/21 8/1 9/11 11/2 13/7. **F.** 1/1 2/26 3/33 4/9 5a/4 5b/2. **G.** 4/15 5/24 6/22 7/17 8/8 9/3 10/1. **H.** 1/8 2/21 2a/8 3/6 4/4 4a/7 5/6 6/2 6a/14 6b/6 7/14 7a/1 8/17 8a/12 8b/11 9/8 10/23 11/12 12/16 13/9 14/17 15/12 16/11. Four species occur in only one area each. **I.** II./1 III./8 V./4 VI./8 VIII./4 XI./3 XII./13 XIII./1 XVIII./9 XX./4. The detailed distribution of several species is of decided interest. The endemic *Lathraea rhodopea* Dingler shows some morphological resemblances with eastern Asiatic species. Beck (in *Bibl. Botan.* IV.) correctly makes a developmental area for eastern species of *Orobanche* in the centre of the Balkan Peninsula. It is interesting to note from his maps that many of the western species reach but do not pass beyond our area, while most of the eastern species (excluding the endemics) pass beyond to the west and north-west. The suggestion is obvious that the east to west migration has been much more important and has extended farther than the west to east. *O. hederae* Duby occurs in Greece, the Athos Peninsula, Thrace, Dalmatia, and Istria. The Oriental *Phelipaea boissieri* Stapf is recorded only from North Macedonia in our area.

Gesneriaceae. 5 species.

A. *Ramondia* 3, *Haberlea* 2. **B.** 4/5. **C.** H/5. **D.** 14/5. **E.** 9/1 11/5. **F.** 3/4 4/2 5a/1 5b/1. **G.** 4/2 5/4 6/4 7/2 8/2 9/1. **H.** 3/1 4/1 5/1 6/2 8/2 8b/1 10/2 **I.** XX./5. All of the 5 species are endemic and represent old types. *Haberlea ferdinandi-coburgii* Urumoff is doubtfully more than a variety of *H. rhodopensis* limited to a small area in North Bulgaria. It keeps distinct in cultivation. *H. rhodopensis* Friv. is endemic to North Bulgaria and the Rodope massif. *Ramondia heldreichii* Benth. et Hook. f. is a very distinct species which has been described as a separate genus, *Jankaea*, by Boissier. It is only known from the Thessalian Olympus. *Ramondia nathaliae* Panč. et Petrov. occurs in North Macedonia and Serbia and *R. serbica* Panč. in Epirus, Albania, North Macedonia, and Serbia. The last two species are very closely related morphologically but, except on the Suva Planina, they are geographically and ecologically separated. The only other species of the family in Europe is *Ramondia pyrenaica* Rich. Repeated attempts to cross reciprocally with *R. serbica* completely failed both ways. The nearest taxonomic allies amongst living plants are to be found amongst recently described Chinese species. *Didissandra sericea* Craib has flowers with a very strong resemblance to those of *Haberlea*. *Boea hygrometrica* R. Br. is superficially very like *Ramondia heldreichii*, except in the fruit which is decidedly different.

Some species of *Oreocharis* and *Dasydesmus* also approach the European members of the family in various characters.

Lentibulariaceae. 10 species.

A. *Pinguicula* 5, *Utricularia* 5. **B.** 4/10. **C.** H/5 HH/5. **D.** 14/5 19/5. **E.** 2/5 4/1 7/3 10/2. **F.** 2/4 3/4 4/3 5a/4 5b/5 5c/3. The altitudinal limits of *Pinguicula grandiflora* Lam. are unknown. **G.** 4/1 5/3 6/6 7/3 8/2 9/1. The flowering periods of 4 species are unknown. **H.** 2/2 3/1 4/2 5/2 6/4 6a/2 8/6 8a/1 8b/2 9/3 10/4 11/3 13/1 14/2 15/1 16/3. Two species occur in only one area each. **I.** II./1 III./1 VI./1 VIII./1 XII./6 XV./2 XX./1. Most species are northern (Central European) in their general distribution. Several have a discontinuous distribution in the Balkan Peninsula. *Pinguicula alpina* L. is known from Epirus, Montenegro, and South Croatia, and *P. grandiflora* only from Hercegovina in our area. *Utricularia bremii* Heer is recorded only from Serbia, and *U. jankae* Vel., endemic to North and South Bulgaria, may be only a variety of *U. vulgaris* L. *U. minor* L. is known from North Macedonia, North Bulgaria (Vitoša), the Dobruja, and Istria. *U. neglecta* Lehm. is recorded from the Dobruja, Dalmatia, and Istria.

Globulariaceae. 7 species.

A. *Globularia* 7. **B.** ħ/1 4/6. **C.** N/1 Ch/3 H/6. **D.** 9/3 14/3 16/3. **E.** 6/2 7/1 9/3 11/3. **F.** 2/2 3/4 4/2 5a/2 5b/1 5c/1. **G.** 2/1 3/1 4/1 5/4 6/3 7/1 9/1. The flowering period of *Globularia trichosantha* Fisch. et Mey. is unknown. **H.** 1/1 2/3 2a/1 3/1 5/2 6/2 6a/3 7/3 8/2 8a/1 8b/3 9/1 10/3 11/3 12/3 13/2 14/3 15/4 16/3. Three species occur in only one area each. **I.** VI./1 IX./1 X./1 XII./3 XIV.a/1 XV./1 XX./1. Four species are essentially Mediterranean and 3 Central European. The latter are for our area Alpine or Carpathian in geographical connexion. *Globularia nudicaulis* L. reaches only into South Croatia.

Acanthaceae. 4 species.

A. *Acanthus* 4. **B.** 4/4. **C.** H/4. **D.** 16/4. **E.** 5/3 9/1 13/2 14/1 16/1. **F.** 2/2 3/3 4/1. **G.** 5/2 6/4 7/4. **H.** 1/1 2/1 2a/1 3/3 4/1 4a/1 5/2 6/1 6a/3 6b/1 7/1 8/1 10/1 11/3 12/2 13/2 14/3 15/3 16/2 **I.** VI./1 X./1 XI./1 XIV./1. *Acanthus longifolius* Host is Pannonian and Balkan Peninsular in its general distribution and the remaining 3 species are Mediterranean. *A. caroli-alexandri* Hausskn. I am unable to distinguish morphologically from *A. syriacus* Boiss., an Oriental species.

Plantaginaceae. 27 species.

A. *Plantago* 26, *Littorella* 1. **B.** 4/17 ②/1 ①/10. **C.** Ch/1 H/16 HH/1 Th/10. **D.** 9/1 14/16 16/1 18/10. **E.** 2/1 3/3 7/11 8/8 9/10 11/3 13/4

14/1 15/1. The habitats of *Plantago alpina* L. and *P. saxatilis* Bieb. are unknown. **F.** 1/7 2/11 3/11 4/7 5a/4 5b/5 5c/5. **G.** 2/2 3/3 4/10 5/17 6/19 7/17 8/11 9/5 10/2. **H.** 1/10 2/13 2a/10 3/11 4/10 4a/10 5/15 6/11 6a/10 6b/6 7/11 7a/1 8/7 8a/9 8b/6 9/8 10/7 11/11 12/7 13/8 14/12 15/8 16/10. Two species occur in only one area each. **I.** I./2 III./3 IV./1 V./6 VI./3 VIII./4 X./2 XI./1 XII./4 XV./2 XVIII./5 XIX./1 XX./2. *Littorella uniflora* Aschers. is known only from the Dobruja in our area. Sixteen species of *Plantago* are Mediterranean, excluding the Balkan Peninsular and endemic species. *P. alpina* L. is recorded from North and South Macedonia. *P. squarrosa* Murr., an East Mediterranean Basin species, is known from the Athos Peninsula.

Rubiaceae. 129 species.

A. *Galium* 70, *Asperula* 46, *Crucianella* 5, *Rubia* 4, *Vaillantia* 2, *Putoria* 1, *Sherardia* 1. **B.** 4/103 ②/1 ①/26. **C.** Ch/84 H/26 G/2 Th/26. **D.** 9/62 12/25 13/3 16/26 17/2 18/26. The perennial species are considerably more numerous than the annual ones, and a large majority are chamaephytes of several types. **E.** 3/5 4/1 5/18 6/21 7/17 8/3 9/41 10/1 11/48 13/10 14/4 15/1 16/1. The habitats of 4 species are unknown. A considerable majority of species occur in rocky and stony habitats. **F.** 1/3 2/52 3/71 4/58 5a/22 5b/26 5c/8. The altitudinal limits of *Asperula pinifolia* Heldr. and *Crucianella macrostachya* Boiss. are unknown. The hill zone has most species, but a considerable number occur in the high mountain zone especially in the southern parts of the Balkan Peninsula. **G.** 2/1 3/5 4/19 5/52 6/84 7/76 8/44 9/7. The flowering periods of 4 species are unknown. Most species are in flower in June and July. **H.** 1/39 2/61 2a/18 3/39 4/29 4a/24 5/38 6/37 6a/33 6b/20 7/42 7a/5 8/45 8a/28 8b/33 9/23 10/40 10a/3 11/44 12/30 13/24 14/30 15/29 16/31. Greece has the largest number of species. **I.** II./2 III./5 IV./2 V./11 VI./12 VII./1 VIII./4 IX./2 X./16 XI./2 XII./20 XIII./7 XIV./5 XIV.a/5 XV./1 XVIII./21 XIX./2 XX./52. Fifty-two species or 40 per cent. are endemic. Forty-eight species, excluding the endemics and Balkan Peninsular types, are of Mediterranean distribution. Forty-one species are limited to one Balkan Peninsular district, and 30 of these are endemic to the Balkan Peninsula in the districts from Thessaly southwards. *Asperula capitata* Kit. is known from Bulgaria, Montenegro, and Hercegovina. *A. littoralis* Sibth. is recorded from Thrace and the Dobruja. *A. tinctoria* L. is found in Thrace, North Bulgaria, Bosnia, South Croatia, and Istria. *Galium incanum* S. et S. occurs in Crete, Greece, Epirus, and the Athos Peninsula. *G. spurium* L. is recorded from Greece, the Cyclades, Thessaly, Epirus, the Dobruja, Montenegro, Bosnia, and Istria.

Caprifoliaceae. 17 species.

A. *Lonicera* 11, *Sambucus* 3, *Viburnum* 3. **B.** ħ/16 ɥ/1. **C.** M/9 N/7 H/1 **D.** 2/1 4/12 5/4 16/1. **E.** 3/2 5/6 6/10 9/3 11/3. **F.** 2/7 3/11 4/13 5a/5. **G.** 3/1 4/4 5/11 6/13 7/7 8/1. **H.** 1/4 2/9 2a/2 3/3 4/5 4a/6 5/9 6/7 6a/8 6b/6 7/7 8/10 8a/3 8b/8 9/4 10/9 11/14 12/10 13/11 14/10 15/11 16/11. **I.** II./2 III./4 IV./4 V./2 VI./5 XII./1 XIV.a/1 XVIII./1 XX./2. Seven species, excluding the 2 endemics, are Mediterranean. *Lonicera hellenica* Orph. occurs in Greece and Thrace.

Adoxaceae. 1 species.

A. *Adoxa* 1. **B.** ɥ/1 **C.** H/1 **D.** 16/1 **E.** 5/1 6/1 **F.** 3/1 4/1 **G.** 3/1 4/1 5/1. **H.** 6/1 6a/1 8/1 9/1 10/1 11/1 12/1 14/1 15/1 16/1. **I.** II./1. The only species, *Adoxa moschatellina* L., does not reach farther south than South Macedonia.

Valerianaceae. 37 species.

A. *Valerianella* 18, *Valeriana* 15, *Kentranthus* 3, *Fedia* 1. **B.** ɥ/17 ①/20. **C.** H/17 G/2 Th/20. **D.** 16/17 17/2 18/20. **E.** 3/3 5/2 7/17 9/10 10/2 11/10 13/10. **F.** 2/21 3/21 4/17 5a/8 5b/8 5c/4. **G.** 2/2 3/7 4/21 5/23 6/19 7/14 8/9 9/2 10/1. The flowering periods of *Valeriana celtica* L. and *Valerianella bulgarica* Vel. are unknown. **H.** 1/13 2/22 2a/4 3/10 4/4 4a/7 5/11 6/10 6a/15 6b/7 7/18 8/12 8a/12 8b/12 9/6 10/11 10a/1 11/14 12/7 13/11 14/13 15/12 16/12. Most species occur in Greece. Six species occur in only one area each. **I.** III./2 IV./2 V./7 VI./8 VIII./1 X./4 XI./2 XII./8 XIII./2 XIV./1 XIV.a/2 XV./2 XVIII./6 XX./7. Twenty-two species are Mediterranean, excluding the endemics. *Valeriana dioica* L. is recorded from Thrace, Serbia, Montenegro, South Croatia, and Istria. *Valerianella costata* Stev. is known from Greece, South Bulgaria, the Rodope massif, the Dobruja, and Dalmatia. *V. eriocarpa* Desv. occurs in Crete, Greece, North Macedonia, Thrace, the Dobruja, Montenegro, Hercegovina, Dalmatia, and Istria.

Dipsacaceae. 83 species.

A. *Scabiosa* 40, *Knautia* 22, *Cephalaria* 9, *Dipsacus* 4, *Pterocephalus* 3, *Succisa* 3, *Callistemma* 1, *Morina* 1. **B.** ɥ/57 ②/10 ①/21. **C.** Ch/12 H/51 G/2 Th/21. **D.** 7/1 9/11 12/1 16/51 17/2 18/21. **E.** 3/1 5/7 6/12 7/27 8/4 9/27 11/20 13/7 14/1 15/2 16/3. The habitats of 6 species are unknown. **F.** 1/1 2/24 3/41 4/39 5a/26 5b/18 5c/7. The altitudinal limits of *Cephalaria sieberi* Szabo and *Scabiosa garganica* Porta et Rigo are unknown. The hill zone has most species, with the second largest number in the montane zone. **G.** 3/1 4/3 5/8 6/35 7/59 8/46 9/15. The flowering periods of 9 species are unknown. The maximum of flowering is in the second half of the year, in July and

August. **H.** 1/8 2/24 2a/3 3/19 4/13 4a/11 5/31 6/25 6a/19 6b/6 7/20 8/29 8a/21 8b/26 9/10 10/29 11/30 12/25 13/21 14/20 15/23 16/15. Albania and Montenegro have each 30 species, North Bulgaria has 29, and Serbia 28. The small numbers of species recorded from the Cyclades and Crete are noteworthy. Twenty species occur in only one district each. **I.** III./3 IV./1 V./5 VI./3 VIII./6 IX./5 X./4 XI./4 XII./14 XIV./3 XIV.a/5 XV./1 XVIII./15 XIX./5 XX./32. The number of endemics, 32 or 38 per cent. is high. Apart from the Caucasian species, the Central European rank next, but the Mediterranean in the broadest sense number 27. *Scabiosa sicula* L. occurs in Crete, South Macedonia, Thrace, South Bulgaria, and the Rodope massif.

Cucurbitaceae. 6 species.

A. *Bryonia* 4, *Colocynthis* 1, *Ecballium* 1. **B.** 4/6. **C.** H/6. **D.** 16/6. **E.** 6/5 8/1 9/1 11/1 16/1. **F.** 1/1 2/4 3/4 4/1. **G.** 3/1 4/3 5/5 6/3 7/3 8/3 9/2. **H.** 1/2 2/4 2a/4 3/2 4/1 4a/1 5/2 6/2 6a/3 7/2 8/2 8a/2 8b/1 9/2 10/2 11/2 13/2 14/3 15/2 16/3. **I.** V./1 VI./1 IX./1 X./1 XI./1 XII./2 XVIII./2. *Bryonia sicula* Guss. occurs in Greece and Sicily. The Oriental *Colocynthis vulgaris* Schrad. is known from the Cyclades.

Campanulaceae. 144 species.

A. *Campanula* 93, *Asyneuma* 11, *Phyteuma* 10, *Hedraeanthus* 8, *Legousia* 5, *Diosphaera* 4, *Jasione* 4, *Symphyandra* 4, *Laurentia* 2, *Adenophora* 1, *Petromarula* 1, *Wahlenbergia* 1. **B.** 4/107 ②/27 ①/14. **C.** Ch/21 H/109 G/5 Th/14. **D.** 9/7 12/15 16/108 17/5 18/14. **E.** 3/2 5/11 6/13 7/33 9/50 11/68 13/6. The majority of species occur in rocky and stony habitats. The habitats of 5 species are unknown. **F.** 1/3 2/31 3/75 4/74 5a/43 5b/34 5c/16. Most species occur in the hill and montane altitudinal zones. The altitudinal limits of *Asyneuma comosiforme* Hayek et Hanch. and *Campanula kladniana* Witasek are unknown. **G.** 3/1 4/18 5/38 6/72 7/101 8/64 9/8 10/2 11/1. The maximum flowering period is in July. There is a sudden rise in species flowering from May to June and on to July, and a still more sudden fall from August to September. The flowering periods of 6 species are unknown. **H.** 1/15 2/34 2a/12 3/32 4/11 4a/11 5/38 6/28 6a/23 6b/14 7/16 7a/2 8/39 8a/15 8b/42 9/13 10/45 10a/3 11/39 12/38 13/22 14/38 15/35 16/23. Most species are found in Serbia, and on the whole there is an increase of species away from the coast, in the inland and in the mountainous districts. Fifty-two species or 36 per cent. occur in one area only, and it is noteworthy that a very large proportion of the species are very limited in their distribution within the Balkan Peninsula. **I.** II./1 III./8 IV./1 V./2 VI./6 VIII./1 IX./4 X./9 XII./22 XIII./2 XIV./8 XIV.a/4 XV./11 XVIII./10

XIX./5 XX./76. The number of endemics is very high, being 76 or 52·8 per cent. Twenty-two species are Mediterranean in the broadest sense, excluding the endemics and Balkan Peninsular types, and 22 are Central European. *Asyneuma canescens* Griseb. et Schenk is recorded from Greece, North Macedonia, North Bulgaria, the Rodope massif, Serbia, Montenegro, Bosnia, and Hercegovina. The 4 species of *Diosphaera* are all endemic to our area. *D. asperuloides* Buser is limited to Greece, *D. chalcidica* Buser to the Athos Peninsula and Rodope massif, *D. rumeliana* Buser to Greece, Thessaly, South Macedonia, the Athos Peninsula, and the Rodope massif, and *D. jacquinii* Buser to Crete. *Jasione bulgarica* Stoy. et Stef. from the Rodope massif is related morphologically to Spanish species. *Petromarula pinnata* DC. is endemic to Crete both as species and genus. *Symphyandra cretica* A. DC. is endemic to Crete and Samothrace (as the var. *samothracica* Degen), *S. hofmannii* Pant. to Bosnia, *S. sporadum* Hal. to the Northern Sporades (Magnesian islands), and the Carpathian *S. wanneri* Heuff. reaches North Bulgaria, the Rodope massif, and Serbia. *Wahlenbergia hederacea* Reichb. is recorded in our area only from Dalmatia.

The genus *Hedraeanthus* deserves special mention. Morphologically it is related to *Wahlenbergia* in the absence of the lateral pores to the capsule, such as are found in species of *Campanula*. It differs in the fruit opening quite irregularly by the perishing of the apical portion. In habit and inflorescence the species more nearly resemble dwarf species of *Campanula* than most species of *Wahlenbergia*. All known species of *Hedraeanthus* except two are endemic to the north-western parts of the Balkan Peninsula. The exceptions are *H. owerinianus* Rupr. of northern Daghestan and *H. graminifolius* DC., the most widely distributed species of the genus, which has its centre of distribution in our area but extends into central and southern Italy, Sicily, and (as the var. *kitaibelii*) northwards into the Banat and Transylvania. The Caucasian species is morphologically most closely related to *H. pumilio* DC. which is only known from several high mountain localities in Bosnia and Dalmatia. It seems difficult to avoid the conclusion that *Hedraeanthus* is an old genus. Most taxonomists stress the value of fruit characters in this section of the *Campanulaceae*. If this holds phylogenetically then it is reasonable to suppose that *Wahlenbergia*, now nearly limited to the southern hemisphere, with a few species in western Europe, the eastern Himalayas, and Japan, had formerly a wider and more continuous distribution in the northern hemisphere and a richer development of species there. In the west of Europe it has survived in only two species of which *W. hederacea* Reichb. just reaches our area in Dalmatia. In the Balkan Peninsula it survived as the off-shoot genus *Hedraeanthus*, several of

whose species flourish at high altitudes. In this sense the genus may be a survival from before the Ice Age. It is impossible to say with certainty which of the species most nearly represents the ancestral type, but I find no reason for rejecting *H. graminifolius*, the most widely distributed species of the genus, as the most likely. The distribution of the genus *Symphyandra* may be compared with that of *Hedraeanthus*. Apart from the species whose distribution is detailed above, and the doubtful *S. panagea* Heldr. et Nadji from South Macedonia, 7 or 8 species occur in the Caucasus and Pontic areas, and *S. asiatica* Nakai [in *Bot. Mag. Tokyo* xxiii. 188 (1909)] in Korea. It is very probable that the genus is polyphyletic and that while the Caucasian-Pontic species have had a common generic origin with the Balkan Peninsular species the eastern Asiatic one has arisen independently.

Compositae. 913 species.

A. *Centaurea* 171, *Senecio* 58, *Crepis* 56, *Cirsium* 43, *Achillea* 41, *Hieracium* 40, *Anthemis* 39, *Carduus* 26, *Artemisia* 23, *Chrysanthemum* 22, *Inula* 21, *Scorzonera* 20, *Tragopogon* 19, *Taraxacum* 17, *Carlina* 16, *Jurinea* 16, *Leontodon* 16, *Echinops* 13, *Lactuca* 12, *Aster* 11, *Helichrysum* 10, *Erigeron* 9, *Gnaphalium* 9, *Hypochaeris* 9, *Onopordon* 9, *Sonchus* 8, *Picris* 7, *Bellis* 6, *Carthamus* 6, *Chondrilla* 6, *Doronicum* 6, *Filago* 6, *Matricaria* 6, *Adenostyles* 5, *Lapsana* 5, *Mulgedium* 5, *Petasites* 5, *Arctium* 4, *Calendula* 4, *Phagnalon* 4, *Pulicaria* 4, *Reichardia* 4, *Staehelina* 4, *Asteriscus* 3, *Bidens* 3, *Cardopatium* 3, *Cichorium* 3, *Evax* 3, *Micropus* 3, *Scolymus* 3, *Serratula* 3, *Xanthium* 3, *Xeranthemum* 3, *Ammanthus* 2, *Anacyclus* 2, *Buphthalmum* 2, *Carpesium* 2, *Cephalorrhynchus* 2, *Chamaepeuce* 2, *Crupina* 2, *Cynara* 2, *Homogyne* 2, *Hymenonema* 2, *Hyoseris* 2, *Pallenis* 2, *Saussurea* 2, *Tolpis* 2, *Urospermum* 2, *Ambrosia* 1, *Amphoricarpus* 1, *Andryala* 1, *Antennaria* 1, *Aposeris* 1, *Arnica* 1, *Arnoseris* 1, *Atractylis* 1, *Bellidium* 1, *Carduncellus* 1, *Catananche* 1, *Chlamydophora* 1, *Cnicus* 1, *Diotis* 1, *Eupatorium* 1, *Galactites* 1, *Hedypnois* 1, *Lagoseris* 1, *Leontopodium* 1, *Notobasis* 1, *Picnomon* 1, *Prenanthes* 1, *Rhagadiolus* 1, *Rodigia* 1, *Santolina* 1, *Silybum* 1, *Solidago* 1, *Tanacetum* 1, *Tussilago* 1, *Tyrimnus* 1, *Willemetia* 1, *Zacyntha* 1. **B.** ♄/4 ϟ/610 ②/154 ①/166. The perennial herbs predominate to such an extent that they form two-thirds of the species. **C.** N/4 Ch/72 H/700 G/7 Th/166. The hemicryptophytes are overwhelmingly dominant. **D.** 4/4 7/128 9/74 14/94 16/629 17/7 18/166. **E.** 3/46 4/1 5/100 6/105 7/274 8/55 9/315 10/12 11/166 12/1 13/106 14/28 15/7 16/67. The habitats of 66 species are unknown. Stony habitats are most common for this family, followed by grassy ones, and these by rocky ones. **F.** 1/48 2/337 3/516 4/378 5a/186 5b/179 5c/72. The altitudinal limits of 22 species are unknown. Most

species occur in the hill altitudinal zone, the next largest number in the montane altitudinal zone, and the next in the lowlands. **G.** 1/9 2/16 3/51 4/119 5/266 6/424 7/588 8/382 9/117 10/27 11/13 12/7. The flowering periods of 81 species are unknown. Most species are flowering in July, the next largest number in June and the next in August. **H.** 1/178 2/443 2a/125 3/271 4/161 4a/89 5/265 6/259 6a/258 6b/82 7/241 7a/19 8/326 8a/198 8b/239 9/176 10/298 10a/18 11/301 12/252 13/231 14/287 15/260 16/230. The greatest number of species, 444, occurs in Greece, the next in North Bulgaria, and the next in Serbia. Two hundred and fifty species occur in only one area each, and of these 184 are endemics. **I.** I./6 II./2 III./110 IV./22 V./37 VI./74 VII./1 VIII./55 IX./22 X./71 XI./21 XII./140 XIII./30 XIV./42 XIV.a/29 XV./39 XVI./1 XVII./2 XVIII./97 XIX./20 XX./327. One hundred and eighteen, or 12·9 per cent. of the species, are very wide in their general distribution; 281 or 30·7 per cent. are Mediterranean; and 140, or over 15 per cent., are Central European in our restricted sense. Three hundred and twenty-seven, or 35·8 per cent., are endemics. In the largest genera the following are the numbers of endemic species. *Centaurea* 114, *Crepis* 20, *Senecio* 17, *Cirsium* 17, *Achillea* 18, *Hieracium* 4, *Anthemis* 18, *Carduus* 7, *Artemisia* 1, *Chrysanthemum* 6, *Inula* 6, *Scorzonera* 6, *Tragopogon* 8, *Taraxacum* 1, *Carlina* 5, *Leontodon* 5, *Jurinea* 9, *Echinops* 6, *Lactuca* 2, *Aster* 2, *Helichrysum* 4. It is necessary to explain that species in the genus *Hieracium* have been accepted in an arbitrary manner by taking only the 'species primariae' in Zahn's monograph in Engler's *Pflanzenreich*.

The *Compositae* are the largest family in the Balkan Peninsular flora, and contain the largest genus, *Centaurea*, which also contains more endemic species than any other genus. The species of *Achillea* have mostly either limited or compact and continuous areas of distribution. The species of *Adenostyles* are apparently either Alpine or Carpathian relative to the Balkan Peninsula. The genus *Ammanthus* is endemic to Crete. *Amphoricarpus neumayeri* Vis. is an isolated type occurring in Albania, North Macedonia, Montenegro, Hercegovina, and Dalmatia. The species of *Anthemis* of our Mediterranean domain show decided eastern affinities or types of distribution. *A. syriaca* Bornm. is recorded from Crete and Syria, but is possibly of independent origin in the two areas (polygenesis). *Artemisia arborescens* L. is typically Mediterranean in its general (VI.) and Balkan Peninsular distribution, it is the only species of the genus which reaches Crete. Most of the species of *Artemisia* show a northern distribution in our area and have apparently invaded it from the north and north-east. *Carduus* is particularly well developed in the Rodope massif whence

11 species are known. *Centaurea* is not only the largest genus in number of species, but is also very abundant in individuals in the summer flora. A considerable number of species have a very limited distribution, thus 82 or nearly one-half, occur in only one area each. While many of these are microspecies taxonomically some are morphologically well differentiated, though they are often more easily defined from living than from dried specimens. I have shown by cultural experiments with wild seed that hybridization occurs in the genus and gives rise to numerous diverse plants, and the probability is that evolution within the genus has been accentuated by this. *Cephalorrhynchus glandulosus* Boiss., an East Mediterranean Basin species, is known only from Thessaly in our area. The species of *Echinops* are mostly morphologically very distinct. The species of *Helichrysum*, except *H. arenarium* DC., are essentially Mediterranean. The genus *Jurinea* is especially well developed in Bulgaria. The species of *Mulgedium* are northern in our area. *Saussurea alpina* DC. and *S. discolor* DC. both occur in our area only in the Rodope massif. *Taraxacum bithynicum* DC. has a Mediterranean Basin general distribution and is known in the Balkan Peninsula from Crete, Albania, and the Rodope massif. *T. fontanum* Hand.-Maz. occurs in Greece, North Macedonia, North Bulgaria, and the Rodope massif. *Urospermum dalechampii* Desv. is recorded from Thrace, Dalmatia, South Croatia, and Istria.

The *Compositae* form the largest family of the *Phanerogamae* in the world's flora, more than 10 per cent. of the known species belonging to it. Within our area 13·9 per cent. of the flowering plants belong to it. The phytogeographical and taxonomic evidence indicates that specific evolution has been rapid within geologically recent times in many of the genera. The predominant habit is that of the perennial herb with a distinctly xeromorphic structure, while a majority of the species are summer flowering. Correlating these facts with the habitat conditions of more than three-quarters of the species (stony, grassy, and rocky habitats), it is reasonable to conclude that there has been an extended distribution of species and an increase in their number as a consequence of forest destruction within the human period. A considerable proportion of the 327 endemics are certainly novitiate species not yet widely dispersed. It is also significant that the number of endemics, 327, contrasts markedly with the number of Balkan Peninsular types, 20. The majority or all of the latter originated, as species, within the Peninsula and have spread only a short distance over its borders. The detailed study of the larger genera has made it clear that this rapid evolution of new species (especially of taxonomic microspecies) is still proceeding.

XIII

PLANT DISPERSAL AND ANIMAL MIGRATIONS

PLANT DISPERSAL.

General. It is pointed out in several places in this work that progressive changes in the flora of the Balkan Peninsula have depended both upon evolution within the area and upon the extension of species into and within it. This latter factor demands a brief discussion of the means by which species extend their distribution, that is of their dispersal.

When commencing my studies on the distribution of the individual species of the Balkan Peninsular flora I attempted to state for each the probable normal method of dispersal. For a few families this was possible for most of the species, but it soon became evident that it was risky to rely, as for most plants I had to rely, solely on the morphological structure in judging of the method of dispersal, and also that in any general summary of figures a very large majority of the species would be under a heading 'means of dispersal unknown'. I therefore concluded that in the present state of our knowledge it was not worth while attempting to obtain any numerical conclusions regarding dispersal for the Balkan Peninsular flora. It is especially in such large families as *Caryophyllaceae*, *Cruciferae*, and *Leguminosae* that one realizes how few are the available data regarding natural dispersal. While it may be true that the study of dispersal is often superfluous in explaining plant distribution, it cannot be ignored in this connexion, even if we only lament our ignorance. There is no evidence that the flora of the Balkan Peninsula is at all peculiar in the dispersal mechanisms of its species. The normal agencies of dispersal are as much in evidence as in any other area and it will be convenient to refer to a few details under the headings of wind, water, and animals.

Wind. The prevalence of strong winds in many districts of the Balkan Peninsula has been fully considered in the chapter on climate. Most often these blow towards the coast and they probably form the most important means of fruit and seed dispersal. The bora and the Vardar winds in winter are of sufficient velocity to carry small seeds even if they have no parachutes. The deforestation of large areas has reduced the obstacles to wind dispersal and has been especially favourable to spreading by blowing along or only slightly above the ground. In February 1917 in South Macedonia I was especially impressed with the quantity of plant detritus blown along and up and down the surface

of the hills north of Salonika. Masses of *Trifolium* infructescences and *Medicago* fruits were being scattered far and wide by this means. The winds gain force when compelled to take a given direction, as up or down a narrow river valley, stream gorge, or nullah. The occasional occurrence of montane or high mountain plants at lower levels is probably due to this. Thus in the gorge coming from the Vitoša above Boyana in 1922 I found several plants below their normal altitude, including *Silene waldsteinii* Griseb. Baldacci has mentioned a similar phenomenon in Albania.

Water. Dispersal by running water can only be down-stream. A majority of aquatic and marsh plants in the Balkan Peninsula, as elsewhere, are without doubt partly dispersed by currents. Occasionally, mainly as a result of floods, rock plants and others are brought to lower levels. Thus after a violent thunderstorm in the Krusa Balkan, in June 1917, I saw the river Spanc carrying down masses of vegetable detritus collected from its erstwhile nearly dry bed and its overflowed banks.

Animals, other than man and domesticated animals. The wild fauna of the Balkan Peninsula has been much reduced in the numbers of larger species since the advent of man. From palaeontological, archaeological, and historical evidence we know that many mammals have become extinct, or have become few and of local range. The lion is extinct, and the bear and deer are limited to a few hardly accessible forests. Wolves are not numerous, but in severe winters packs and individuals hunt for food over wide areas, as is shown by recently published accounts of their appearance in villages of the Karst and in the outer streets of Sofia. Foxes and hares and other rodents abound in the hills. Hares and rabbits are especially common in the Cyclades. The two species are said never to occupy the same area. Thus Naxos, Melos, and Tenos have only hares, Seriphos, Kimolos, and Mykonos only rabbits, while in Andros hares alone occur in the northern and rabbits in the southern part of the island. Squirrels, wild boars, wild cats, and jackals also occur but are much less common. It is obvious that even now, but much more in the past, the mammalian fauna, from its variety and from the numbers of individuals, must be considered as an important factor in seed dispersal by the attachment of fruits and seeds to the animals' coats. The avian fauna of our area is very rich in species and individuals. An interesting exhibit of birds shot on the Balkan front by officers of the Black Watch has been exhibited for some years in the Natural History Museum, South Kensington. One feature of the bird life is the abundance of ducks and geese in the many marshes of the central and northern districts of the Peninsula. Remembering that the importance of these birds as distributors of plant

species has been proved by the observations of Woodruffe-Peacock and others in the British Isles we may be sure that in Macedonia, Serbia, and Bulgaria especially they help in the wide dispersal, more particularly of marsh species. Fruit and seed-eating birds are abundant in the forests and brushwoods, though, unfortunately, I have no records of examinations of the crops of birds killed in the Balkan Peninsula. Numerous migrants—summer and winter—are known in the Balkan Peninsula and though the dispersal of many plants by birds migrating long distances is not proved, it probably happens occasionally with individual species. Insects of many kinds occur abundantly in all districts, but it is sufficient here to mention the numerous species of ants whose very local movements of fruits and seeds may have some cumulative effect on plant dispersal on a wider scale.

Man. One of the most important agencies in the dispersal of plants in recent times has been man and his domesticated animals. This subject is most important also from other points of view and has therefore been considered separately in Chapter X.

ANIMAL MIGRATION.

The probable routes of animal migration into and through the Balkan Peninsula are of importance in connexion with plant dispersal and also for comparison with the routes of plant migration and extension. The conception of a Mediterranean Region with two divisions, Mediterranean Basin and Orient, is well established botanically. This Mediterranean Region is, moreover, strongly contrasted in its plant life with a Central European Region. There seem, however, to be insufficient reasons for making corresponding divisions on a zoological basis, though, it may be noted, the botanical divisions are of great significance in the study of 'human geography'.

The migrations of animals allow of only partial comparison with the dispersal of plants and the extension or modification of their areas of distribution. The seasonal migration of birds, for example, has no counterpart amongst plants. Within the Mediterranean Basin bird migration is mainly north to south and the reverse. C. Suffern [1] has distinguished three main routes across the Mediterranean Sea, one of which, from Egypt to Crete and Greece, impinges on our area. It has been suggested that bird migration routes across open seas often indicate old land connexions, but it is at least doubtful if the suggestion has any value here, for the route is the one that would most likely be chosen because it involves the shortest sea-crossing in the eastern Mediterranean Basin.

The route of the 'Oriental migration' seems well established for

[1] *British Birds*, xiii. 173, 1919.

animals, as in this work it is for plants, and to have been in use through much of Tertiary time. R. F. Scharff [1] has distinguished an Oriental from a Siberian migration. He concludes that the former has influenced the fauna of Europe more than any other migration. It was long persisting, and its results can be traced from one end of the continent to the other. The route followed was over the old Aegean continent and through the Balkan Peninsula. Probably commencing before the Miocene period it persisted till the formation of the Aegean Sea in post-glacial times. The migrants included mammals (deer, *Elephas*, camel, &c.), many genera of birds, reptiles, and amphibians (certain lizards, toads, tree-frog, &c.), as well as insects (*Papilio*, *Parnassius*, *Colia*, *Danais*, *Hopatroides*, *Amphicoma*, *Mantis*, *Bacillus*, &c.) and the freshwater crab (*Thelphusa fluviatilis*). The discontinuous distribution of certain existing animals, like that of certain plants, is also evidence of the importance of the Oriental route. Thus the goat of Asia Minor (*Capra aegagrus*) occurs on the island of Crete and on some of the Cyclades. Animals extending their distribution north of the Balkan Peninsula in Miocene and Pliocene times had their way barred by the Sarmatic Sea or interrupted by the Pontic lake or lakes. The gradual emergence of the Alps opened a north-western route, and any land connexions there may have been between Greece and Dalmatia on the one side and parts of South Italy and Sicily and North Africa on the other would give a southern route to the west.

The probabilities of a land connexion with Africa in Tertiary times require more detailed consideration than can be given them here. The Pikermi deposits contain the bones of animals, many of which appear to indicate an African affinity, but it is possible that the connexion with Africa was indirect and through western Asia. Certainly the African forms represented as fossils in these deposits seem to have left very little impression on the existing fauna. Very similar conclusions have been reached by a study of the existing plant life and the relatively few records of fossil plants.

As with plants, so with animals, certain groups have or have had an active centre of development and distribution in the Balkan Peninsula. Some land mollusca (as the genus *Clausilia*) are an excellent example. Another centre of development for the same or closely allied genera is found in the Iberian Peninsula, but for reasons not fully understood migration westwards of Oriental species has been more pronounced than migration eastwards of 'Lusitanian' species. This again agrees with what we find for the plant distribution of the Mediterranean Region.

[1] *The History of the European Fauna* (London, 1899), especially Chapters V and VI.

XIV

FLORISTIC AND VEGETATIONAL DISTRIBUTION WITHIN THE BALKAN PENINSULA

General. The boundaries and physiographic details of the districts into which the Balkan Peninsula has been divided for the purposes of this work have been given in Chapter I. It is there explained that the districts were chosen as convenient working units and, after various modifications had been introduced, they were found excellent for this purpose. It must be emphasized again that the districts were not delimited as phytogeographical units. To have attempted to divide the area into botanical districts would have been equivalent to putting the cart before the horse and would have been a failure. The inductive method which has been followed readily permits any kind of analysis and synthesis and, moreover, allows of modifications as more data become available in the future.[1]

The following table shows the distribution in the districts of the species of each family; this is succeeded by an account of the floristic and vegetational characteristics of each district, and by the conclusions reached regarding the botanical subdivision of the Balkan Peninsula.

DISTRIBUTION, ETC. WITHIN THE DISTRICTS

It will be seen that Greece is the district with most species. It is followed in the order given by North Bulgaria, Serbia, Montenegro, Dalmatia, and South Croatia. It is interesting to note the relatively high number of species in the Montenegrin flora in spite of the small size of the country. It was not feasible to make districts all of the same area because of the great irregularity of the coast-line and the inequality of botanical exploration in different parts. In the detailed discussion of each district given below these and other factors have been considered in the conclusions drawn.

1. **Crete.** This is the most southern of our districts and the largest that is entirely surrounded by the sea. It is the fifth largest island in the Mediterranean Sea, being only a little smaller than Corsica. It is essentially a mountainous and hilly island, in Mt. Ida rising to 2,457 m. Geologically it is of interest in having been the first of the islands and

[1] All the tables on pp. 311–315 are based on data recorded on 'loose leaf' slips, which can be added to indefinitely, and the basis of every single record can be traced and checked immediately any doubt arises.

DISTRIBUTION OF THE SPECIES OF EACH FAMILY IN THE DISTRICTS OF THE BALKAN PENINSULA

	1. *Crete*	2. *Greece*	2a. *Cyclades*	3. *Thessaly*	4. *Epirus*	4a. *Corfu*	5. *Albania*	6. *N. Maced.*	6a. *S. Maced.*	6b. *Athos.*	7. *Thrace*	7a. *Thrac. Is.*	8. *N. Bulg.*	8a. *S. Bulg.*	8b. *Rodope*	9. *Dobruja*	10. *Serbia*	10a. *Novi Pazar*	11. *Montenegro*	12. *Bosnia*	13. *Herceg.*	14. *Dalmatia*	15. *S. Croatia*	16. *Istria*
Taxaceae	..	1	..	1	..	..	1	1	1	1	..	..	1	1	1	..	1	..	1	1	1	..	1	1
Pinaceae	6	11	4	7	5	4	13	12	7	7	8	1	9	1	12	..	11	5	12	7	12	12	8	7
Gnetaceae	1	2	1	1	1	1	2	2	2	1	2	..	1	..	..	1	..	..	2	1	2	3	1	1
Typhaceae	1	1	1	3	2	1	3	2	3	..	3	..	2	3	1	4	4	..	2	3	1	3	3	2
Sparganiaceae	..	2	..	1	1	..	1	1	1	..	1	..	2	1	3	1	3	..	2	3	2	2	3	1
Potamogetonaceae	7	13	4	11	5	8	7	7	10	1	12	1	13	8	..	10	14	..	17	11	10	14	16	17
Naiadaceae	..	1	..	1	..	..	2	..	..	..	1	..	2	1	..	1	2	..	2	1	1	1	1	2
Scheuchzeriaceae	1	2	..	..	..	1	..	..	..	..	..	..	1	1	..	1	1	..	1	1	1	2	2	2
Alismataceae	1	3	..	1	3	1	1	1	2	..	2	..	4	1	1	2	3	..	2	3	2	3	4	3
Butomaceae	..	1	..	1	1	1	1	1	1	..	1	..	1	1	1	1	1	..	1	1	1	1	1	1
Hydrocharitaceae	..	2	..	..	1	..	..	2	1	..	1	..	2	1	..	3	2	..	..	1	1	1	1	..
Gramineae	119	195	104	145	83	125	130	111	148	39	158	5	167	134	107	75	169	11	165	139	138	176	169	162
Cyperaceae	25	49	14	45	12	27	31	46	32	11	48	..	74	48	28	29	83	2	69	58	45	50	67	58
Araceae	5	8	5	4	2	4	1	1	3	1	4	1	2	3	..	1	3	..	3	3	3	6	5	4
Lemnaceae	1	4	1	1	1	2	1	3	3	..	4	..	3	5	1	5	4	..	1	3	..	4	2	4
Juncaceae	10	17	7	16	6	5	5	18	19	4	16	..	23	11	17	7	23	..	21	19	14	16	21	20
Liliaceae	48	112	51	57	28	23	50	63	62	25	67	3	91	79	55	44	75	3	65	57	72	77	68	69
Amaryllidaceae	5	12	5	3	2	3	8	5	6	2	9	..	5	6	5	3	8	1	6	5	5	13	5	6
Dioscoreaceae	1	1	1	1	1	1	2	1	1	..	1	..	1	1	1	..	1	..	1	1	1	1	1	1
Iridaceae	18	27	13	11	5	11	15	11	20	3	23	..	17	20	11	8	22	1	18	12	15	17	13	15
Orchidaceae	39	63	13	20	8	24	34	24	39	8	44	1	39	24	31	18	47	2	44	52	40	51	39	55
Salicaceae	4	12	3	7	4	..	6	11	10	3	8	1	17	7	12	7	15	3	15	18	15	8	19	12
Juglandaceae	..	1	..	1	1	..	1	1	1	..	1	..	1	1	1	1	1	1	1	1	1	..	1	..

DISTRIBUTION OF THE SPECIES OF EACH FAMILY IN THE DISTRICTS OF THE BALKAN PENINSULA (*continued*)

	1. *Crete*	2. *Greece.*	2a. *Cyclades*	3. *Thessaly*	4. *Epirus*	4a. *Corfu*	5. *Albania*	6. *N. Maced.*	6a. *S. Maced.*	6b. *Athos*	7. *Thrace*	7a. *Thrac. Is.*	8. *N. Bulg.*	8a. *S. Bulg.*	8b. *Rodope*	9. *Dobrusja.*	10. *Serbia*	10a. *Novi Pazar*	11. *Montenegro*	12. *Bosnia*	13. *Herceg.*	14. *Dalmatia*	15. *S. Croatia*	16. *Istria*
Betulaceae	..	6	1	6	3	..	6	8	5	6	7	..	7	4	8	4	8	5	8	9	7	4	9	8
Fagaceae	5	11	5	12	10	2	13	7	10	5	10	1	5	7	7	6	8	5	12	9	10	10	9	10
Ulmaceae	3	4	2	3	..	..	4	2	2	..	2	..	4	4	3	2	3	1	3	3	4	2	4	2
Moraceae	1	2	1	2	1	1	2	2	2	1	2	1	2	2	2	2	1	..	2	2	2	2	2	2
Urticaceae	7	8	7	3	3	4	6	4	6	1	7	1	4	3	3	5	5	1	7	3	5	6	3	5
Loranthaceae	1	3	..	3	2	..	3	3	3	2	3	..	2	..	2	2	3	..	1	3	3	3	3	3
Santalaceae	3	5	3	4	2	2	7	8	4	2	7	..	9	6	4	2	6	..	8	7	8	6	7	5
Aristolochiaceae	2	5	3	2	1	2	3	3	5	2	5	..	4	1	3	2	3	1	4	4	4	4	4	4
Rafflesiaceae	1	1	1	..	..	1	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	1	..	1
Polygonaceae	15	27	10	28	16	11	25	22	25	10	23	..	28	23	16	19	29	4	23	25	21	20	28	21
Chenopodiaceae	15	30	20	21	9	13	18	12	27	5	35	..	31	26	12	40	29	2	13	14	16	24	24	28
Amarantaceae	2	6	2	5	2	..	4	3	5	1	6	..	5	5	1	2	3	2	3	5	5	4	4	5
Cynocrambaceae	1	1	..	1	..	1	1	..	..	1	1	..	..	..	1	..	..	..	1	..	1	1	..	1
Phytolaccaceae	1	1	..	1	..	..	1	..	1	1	1	..	1	1	..	..	1	..	1	1	1	1	..	1
Aizoaceae	3	3	4	2	..	..	1	..	1	1	2	..	1	..	..	..	..	..	..	..	..	2	..	..
Portulacaceae	1	2	1	2	1	1	1	2	2	..	2	1	1	2	..	1	2	..	2	2	2	1	1	1
Caryophyllaceae	71	177	55	120	63	26	124	147	133	31	105	16	142	91	132	75	132	14	121	122	109	99	100	71
Nymphaeaceae	..	2	..	2	2	1	2	2	2	..	2	..	2	1	..	3	2	..	3	1	2	2	2	2
Ceratophyllaceae	..	1	1	2	..	..	1	2	2	..	1	..	1	2	..	3	2	..	1	1	..	1	..	2
Ranunculaceae	31	68	23	46	16	23	59	63	57	13	65	2	79	57	51	36	87	8	77	64	56	69	77	64
Berberidaceae	2	3	2	2	..	..	2	1	1	1	3	1	1	2	1	2	2	..	1	2	1	1	2	1
Lauraceae	1	1	..	1	1	..	1	..	..	1	1	..	..	..	..	..	..	..	..	..	1	1	1	1
Papaveraceae	14	32	14	13	8	8	15	23	22	3	20	1	19	17	9	15	19	2	13	8	12	24	16	19
Cruciferae	61	157	52	106	59	43	96	135	113	33	102	7	119	87	91	81	124	8	120	102	83	125	108	86

Capparidaceae	2	2	1	1	..	..	1	1	3	1	2	..	..	1	1	..	..	..	1	..	..	2	1	2
Resedaceae	3	5	4	4	2	2	..	5	4	2	3	..	3	2	2	4	4	..	3	2	4	5	3	3
Droseraceae	..	..	..	..	..	..	..	2	1	..	..	..	1	..	1	1	2	..	..	..	..	1	..	..
Crassulaceae	23	31	11	24	7	8	19	27	22	13	17	2	27	16	21	5	21	2	19	15	16	19	14	11
Saxifragaceae	3	18	2	13	10	2	20	19	11	6	2	..	14	3	28	1	20	2	26	20	16	9	16	10
Platanaceae	1	1	1	1	..	..	1	1	1	1	1	..	..	1	1	..	..	..	..	..	..	..	..	..
Rosaceae	20	65	12	68	40	13	75	61	62	25	46	7	93	41	81	38	104	19	96	104	87	51	85	80
Leguminosae	147	288	135	157	100	96	183	207	205	81	241	10	191	158	134	99	179	29	201	155	165	244	167	184
Geraniaceae	11	29	16	21	7	15	24	24	19	4	22	..	18	16	16	16	21	3	22	20	20	24	18	17
Oxalidaceae	2	3	1	2	..	2	2	1	2	..	2	1	2	..	2	..	2	..	2	1	2	1	2	2
Linaceae	9	17	6	14	4	6	15	17	12	6	16	1	15	14	12	7	17	..	14	9	16	15	16	13
Zygophyllaceae	4	2	2	2	1	1	1	2	1	..	2	..	2	..	..	3	2	..	..	1	1	1	1	1
Rutaceae	3	5	1	3	2	1	7	5	3	1	6	..	4	2	4	3	4	..	3	3	4	5	5	5
Polygalaceae	3	8	2	4	2	3	8	7	5	2	8	..	4	8	8	3	6	1	7	8	6	6	5	6
Euphorbiaceae	24	39	21	24	9	11	27	21	35	14	33	3	27	25	16	17	34	3	29	29	30	34	27	31
Callitrichaceae	..	5	..	2	..	3	2	1	..	..	2	..	2	1	1	..	2	..	4	..	..	4	13	2
Buxaceae	..	1	..	1	1	..	1	1	1	..	1	..	..	..	..	..	..	..	..	..	..	1	..	..
Empetraceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	1	1	..	..	..	..
Coriariaceae	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Anacardiaceae	2	4	..	4	3	1	4	5	4	3	4	..	2	2	2	1	1	..	3	1	4	4	3	3
Aquifoliaceae	..	1	..	1	1	1	1	1	1	1	1	..	1	1	1	..	1	..	1	1	1	1	1	1
Celastraceae	..	2	..	2	..	1	2	4	4	1	1	..	3	4	4	2	3	..	3	3	2	2	2	3
Staphyleaceae	..	..	..	..	..	..	..	..	..	..	..	..	1	..	1	1	1	..	1	1	..	..	1	1
Aceraceae	1	5	..	6	4	..	7	7	7	4	3	..	6	3	4	3	7	1	7	8	8	6	6	4
Hippocastanaceae	..	1	..	1	1	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..
Balsaminaceae	..	..	..	..	..	..	..	..	1	..	..	..	1	1	1	..	1	..	1	1	1	..	1	1
Rhamnaceae	5	11	4	6	2	4	12	8	6	3	4	..	6	5	7	4	5	..	8	6	7	8	1	7
Vitaceae	1	1	..	1	1	..	1	1	1	..	1	..	..	1	1	1	..	1	..	1	1	1	1	1
Tiliaceae	..	2	..	2	1	1	1	3	4	1	3	..	4	1	3	2	4	..	4	4	2	3	4	2
Malvaceae	14	22	12	15	5	10	11	14	15	3	16	..	13	11	9	10	16	2	13	10	12	19	11	14
Hypericaceae	9	18	9	5	1	1	10	13	14	10	18	3	17	15	14	4	16	1	6	8	7	5	8	5
Elatinaceae	1	1	..	..	..	1	..	..	..	..	..	..	3	1	..	..	2	..	..	..	..	..	..	..
Frankeniaceae	2	2	2	..	..	..	..	..	..	..	2	..	..	1	..	2	..	..	..	..	..	1	..	..

DISTRIBUTION OF THE SPECIES OF EACH FAMILY IN THE DISTRICTS OF THE BALKAN PENINSULA (*continued*)

	1. *Crete*	2. *Greece*	2a. *Cyclades*	3. *Thessaly*	4. *Epirus*	4a. *Corfu*	5. *Albania*	6. *N. Maced.*	6a. *S. Maced.*	6b. *Athos*	7. *Thrace*	7a. *Thrac. Is.*	8. *N. Bulg.*	8a. *S. Bulg.*	8b. *Rodope*	9. *Dobrujа*	10. *Serbia*	10a. *Novi Pazar*	11. *Montenegro*	12. *Bosnia*	13. *Hercg.*	14. *Dalmatia*	15. *S. Croatia*	16. *Istria*
Tamaricaceae	4	5	1	2	1	2	3	2	3	..	3	..	..	2	..	2	..	..	..	..	1	2	..	..
Cistaceae	12	18	9	10	4	7	17	11	10	5	11	..	6	9	7	3	9	1	13	9	12	18	13	12
Violaceae	8	13	1	9	4	..	15	23	11	7	5	1	18	7	17	9	18	1	3	14	13	7	12	11
Datiscaceae	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Thymelaeaceae	5	9	2	4	2	1	7	6	6	3	7	..	6	1	6	1	7	..	5	6	4	5	5	5
Elaeagnaceae	1	1	1	..	..	1	..	1	1	..	2	..	2	..	..	2	..	..	..	..	..	1	1	..
Lythraceae	2	5	2	5	3	3	4	2	4	2	6	..	4	6	3	3	6	..	6	3	1	4	4	3
Punicaceae	1	1	..	1	..	..	1	1	1	..	1	1	..	..	..	..	..	..	1	..	1	1	..	1
Myrtaceae	1	1	1	1	1	1	1	..	..	..	1	1	..	..	..	..	..	..	1	..	1	1	1	1
Oenotheraceae	3	12	2	12	6	2	11	12	10	5	8	1	16	6	14	7	16	2	16	15	15	8	17	10
Hippuridaceae	1	2	..	2	1	1	3	2	2	..	2	..	3	1	..	2	3	..	3	1	1	2	2	3
Cynomoriaceae	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Araliaceae	1	2	..	2	1	..	1	1	1	1	2	1	1	..	1	1	1	..	1	1	1	1	1	1
Umbelliferae	68	133	51	103	51	27	93	93	95	36	98	4	128	79	81	65	127	15	125	97	102	128	123	97
Cornaceae	..	2	1	2	..	1	2	1	2	..	3	..	3	1	1	2	2	1	2	2	2	2	2	2
Pirolaceae	..	2	..	3	..	..	4	2	3	1	..	..	6	..	5	..	7	..	5	5	1	..	6	2
Ericaceae	4	4	4	4	4	3	7	4	6	5	6	2	6	4	7	..	7	1	5	5	6	9	10	5
Primulaceae	13	18	6	14	6	6	22	19	18	7	16	2	24	11	19	8	24	5	17	17	18	16	20	13
Plumbaginaceae	9	18	11	5	4	2	6	10	12	5	12	1	10	8	6	8	8	..	4	1	5	4	3	4
Ebenaceae	..	1	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	1	1	..
Styracaceae	1	1	1	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	1	..	..
Oleaceae	2	7	1	6	7	2	9	7	7	2	8	1	7	5	5	6	4	4	8	5	16	7	9	8
Gentianaceae	6	9	4	10	5	6	18	16	7	4	9	..	21	5	16	6	21	2	27	20	14	16	19	15
Apocynaceae	2	2	1	2	..	1	1	3	4	..	5	..	4	2	..	2	2	..	1	1	..	2	3	2

Asclepiadaceae	4	7	3	5	1	2	7	5	7	5	5	1	4	3	5	4	1	..	6	..	4	8	3	4
Convolvulaceae	15	25	13	12	7	8	9	9	11	4	16	1	9	9	8	11	11	..	9	5	7	12	9	8
Polemoniaceae	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	1	..	..	..	..
Borraginaceae	37	78	34	43	27	23	46	56	61	8	62	3	63	55	46	38	45	3	46	38	36	45	34	34
Verbenaceae	4	4	2	3	2	3	3	1	2	1	4	1	1	2	2	1	1	1	1	1	2	2	2	2
Labiatae	76	162	52	114	73	48	106	117	122	36	115	16	130	104	103	63	125	9	109	79	89	116	91	86
Solanaceae	7	12	6	8	6	5	8	5	8	4	9	..	7	5	6	5	7	1	7	6	8	9	8	9
Scrophulariaceae	41	96	33	81	41	32	89	95	85	26	71	6	116	73	95	43	107	11	115	100	89	79	93	82
Orobanchaceae	8	21	8	6	4	7	6	2	14	6	14	1	17	12	11	8	23	..	12	16	9	17	12	11
Gesneriaceae	..	..	..	1	1	..	1	2	..	..	..	..	2	..	1	..	..	..	..	..	..	..	..	..
Lentibulariaceae	..	2	..	1	2	..	2	4	2	..	..	..	6	1	2	3	4	..	3	..	1	2	1	3
Globulariaceae	1	3	1	1	..	..	2	2	3	..	3	..	2	1	3	1	3	..	3	3	2	3	4	3
Acanthaceae	1	1	1	3	1	1	2	1	3	1	1	..	1	..	..	..	1	..	3	2	2	3	3	2
Plantaginaceae	10	13	10	11	10	10	15	11	10	6	11	1	7	9	6	8	7	..	11	7	8	12	8	10
Rubiaceae	39	61	18	39	29	24	38	37	33	20	42	5	45	28	33	23	40	3	44	30	24	30	29	31
Caprifoliaceae	4	9	2	3	5	6	9	7	8	6	7	..	10	3	8	4	9	..	14	10	11	10	11	11
Adoxaceae	..	..	..	..	..	..	..	1	1	..	..	..	1	..	..	1	1	..	1	1	..	1	1	1
Valerianaceae	13	22	4	10	4	7	11	10	15	7	18	..	12	12	12	6	11	1	14	7	11	13	12	12
Dipsacaceae	8	24	3	19	13	11	31	25	19	6	20	..	29	21	26	10	29	..	30	25	21	20	23	15
Cucurbitaceae	2	4	4	2	1	1	2	2	3	..	2	..	2	2	1	2	2	..	2	..	2	3	2	3
Campanulaceae	15	34	12	32	11	11	38	28	23	14	16	2	39	15	42	13	45	3	39	38	22	38	35	23
Compositae	178	443	125	271	161	89	265	259	258	82	241	19	326	198	239	176	298	18	301	252	231	287	260	230
Totals:																								
Gymnospermae	7	14	5	9	6	5	16	15	10	9	10	1	11	2	13	1	12	5	15	9	15	15	10	9
Monocotyledoneae	281	513	219	321	161	237	292	297	351	94	395	11	449	348	262	213	465	20	420	373	352	438	421	422
Dicotyledoneae	1144	2446	882	1642	907	676	1751	1814	1774	620	1743	130	2040	1383	1572	1084	1993	203	1927	1640	1573	1839	1729	1539
Totals of all classes	1432	2973	1106	1972	1074	918	2059	2116	2135	723	2148	142	2500	1733	1847	1298	2470	228	2362	2022	1940	2292	2160	1970

island groups to be separated from the Balkan–Aegean–Asia Minor continental land mass, and a connexion with Cyrenaica even to Pleistocene times has been suggested on structural and tectonic grounds. Crete lies entirely within the zone of Mediterranean climate.

One thousand four hundred and thirty-two species of Phanerogams are known from Crete. This is less than half the number from Greece (as here limited), which is much larger and has greater diversity of topographical and climatic conditions. One thousand two hundred and eight species are common to Crete and Greece, to Crete and the Cyclades, or to all three districts. Also 29 species occur in Crete and the Balkan Peninsula but are not known from Greece. Thirty-seven species occur only in Crete and Greece, in these two districts and in the Cyclades, or in Crete and the Cyclades, i.e. they are endemic to the joint area of the three districts. In addition 23 species are endemic to Crete and the Balkan Peninsula, but extend north of Greece and the Cyclades. These figures are in marked contrast with the results obtained from a comparison of the flora of Cyrenaica and Tripoli with that of the Balkan Peninsula (see pp. 413–416) and prove that the floristic connexion of Crete is very much closer with the Balkan Peninsula, and especially with Greece and the Cyclades, than it is with North Africa, though it is almost as close with Asia Minor.

The predominant families in the Cretan flora are: *Gramineae* (119), *Liliaceae* (48), *Orchidaceae* (39), *Caryophyllaceae* (71), *Ranunculaceae* (31), *Cruciferae* (61), *Leguminosae* (147), *Umbelliferae* (68), *Borraginaceae* (37), *Labiatae* (76), *Scrophulariaceae* (41), *Rubiaceae* (39), and *Compositae* (178). Twenty-seven families represented in the whole Balkan Peninsular flora are absent from Crete. The most important of these are the *Betulaceae*, *Tiliaceae*, and *Lentibulariaceae*. The *Datiscaceae* and *Cynomoriaceae* are represented, each by one species, in Crete alone of the Balkan Peninsular districts.

Two hundred and one species endemic to the Balkan Peninsula occur in Crete, and of these 131 are limited to the island. Many of them are taxonomically isolated types, and indicate a considerable period of isolation. There are four chief centres of endemism, namely, the Sphakia mountains in the west, the richest area, Psiloriti in the centre with Mt. Ida, Lassiti in the east, and the Sitia mountains and peninsula still farther east. Nearly all the endemics are plants of rocky or stony places, occurring especially in rocky ravines in the montane or high-mountain altitudinal zones. Most of them are Oriental in their general affinity, that is the genus or section to which they belong has a chief centre of distribution in the Orient, though many are taxonomically related to species of the Cretan or Greek floras. The neo-endemics are less numerous in Crete and the palaeo-endemics more numerous, relative

to the total endemism, than in other districts in the Balkan Peninsula. There are also many altitudinally vicarious[1] and geographically pseudo-vicarious[1] species among them.

The Mediterranean coastal macchie have been very largely destroyed, but areas of macchie occur at higher altitudes than in any other of our districts. The forests also have been ruthlessly exploited and the predominant community is the phrygana. Aquatic plants are very poorly represented.

Crete, with the few small islands around it forms a natural district of the Mediterranean domain. From the Cyclades it is differentiated by its much higher altitudes, and in flora and vegetation it is most nearly related to Greece, but its smaller flora, which is, however, rich in endemics unknown from Greece, necessitates its being kept as a distinct botanical district. Floristically Crete is a piece of Asia rather than of Europe. It has been relatively fairly well explored, but there is still much to be done, especially in the south and east. No notice should be taken of Gandoger's *Flora Cretica* unless his specimens are available for reference. Fortunately there is a large set at Kew and I have thus been able to reduce a considerable number of his so-called new species.

2. **Greece.** This is the second largest of our districts and the most southern of those with part of their boundary inland. It is extremely mountainous and hilly, cross-country communications being very difficult. Its highest mountain is probably Vardusia, 2,495 m., though Parnassus (2,459 m.) and the highest peak of the Peloponnese, Kyllene or Ziria (2,374 m.), are nearly as high. The most noteworthy of the topographical features is the great Gulf of Corinth, which almost separates the Peloponnese from northern Greece. When further botanical exploration and collecting has been done it will probably prove desirable to separate as districts the Peloponnese, northern Greece, and Euboea. The Tertiary connexion with Asia Minor is the most interesting feature of the geological history. It lasted to relatively recent times and has had a profound effect on the flora. Much of the country is of Mesozoic age and limestones predominate. The whole area lies within the Mediterranean climatic region, though, apart from differences due to altitude, there are considerable ranges in temperature and rainfall. The eastern side is much drier than the western, and in the north the effects of distance from the sea and the proximity of the Pindus range and its offshoots are marked.

[1] By *vicarious* is meant having distinct but contiguous distributional areas, and by *pseudo-vicarious* having distinct but not contiguous distributional areas. The areas may be one above the other (*altitudinally vicarious* or *pseudo-vicarious*), or may have distinct limits of latitude and longitude (*geographically vicarious* or *pseudo-vicarious*).

Two thousand nine hundred and seventy-three Phanerogams are known from Greece, the largest number for any one of our districts. Five hundred and sixty-four of these are endemic to the Balkan Peninsula as a whole, including 260 which are endemic to Greece alone. The affinities of the flora are with Asia Minor, and the whole aspect of the flora and vegetation is Oriental. The Central European element, even in the montane and high mountain altitudinal zones, is very small.

The predominant families are: *Gramineae* (195), *Cyperaceae* (49), *Liliaceae* (112), *Orchidaceae* (63), *Caryophyllaceae* (177), *Ranunculaceae* (68), *Papaveraceae* (32), *Cruciferae* (157), *Crassulaceae* (31), *Leguminosae* (288), *Umbelliferae* (133), *Borraginaceae* (78), *Labiatae* (162), *Scrophulariaceae* (96), *Rubiaceae* (61), *Campanulaceae* (34), and *Compositae* (443). Nine families occur in the Balkan Peninsula as a whole, which are absent from Greece. The *Coriariaceae*, with one species, is the only family in the Greek flora which is known from no other district of the Balkan Peninsula.

The Mediterranean macchie, pseudomacchie, and the phrygana are the dominant types of plant communities in the lowland and hill zones, in which the woods have been largely destroyed. The weed vegetation is also very rich. In the less accessible montane and high mountain parts forests still exist, especially of *Abies cephalonica* Loud. Aquatic communities are of very local occurrence, but the maritime communities are fairly well represented. Probably phrygana, of one kind or another, covers more area than any other plant community outside the cultivated land, especially in eastern Greece. The large proportion of suffruticose plants, such as numerous *Labiatae*, is striking, both when considered as individuals and as species. Many genera, most of whose species are herbaceous, have, in Greece and Crete, shrubby or suffruticose representatives. Examples are *Dianthus*, *Silene*, *Linum*, and *Scabiosa*.

The vegetation of western Greece is much more luxuriant than that of the eastern parts, though typically Mediterranean. This is connected with the wetter climate and, to a less degree, with the historical fact that the more important Greek city-states were to the east or south.

The district is surrounded on all sides except the north by the sea. The Othrys mountains are a natural boundary separating Greece from Thessaly. Though these mountains are relatively low, reaching only to 1,728 m. in the highest peak, they form an important floristic barrier which would be still more pronounced were it not for the relatively continuous southern extension, farther west, of the Pindus 'backbone'. In the centre and west the northern boundary is an artificial one, and the data available do not permit its replacement by

a more accurate botanical division, except to indicate that the Pindus range might be considered as a separate district projecting the Central Balkan Peninsular flora into that of the Mediterranean domain. The islands Leukas, Cephalonia, and Zante should certainly be joined botanically to Greece, the two former with northern Greece and Zante with the Peloponnese. The Magnesian islands are best linked with Euboea till their flora has been more fully investigated.

Floristically Greece is fairly well known, though there are probably a considerable number of species still to be recorded and our knowledge of the detailed distribution of many is very imperfect. The least studied parts are in the north-west, where the district meets Epirus, and in the north centre, that is the area of the southern offshoots of the Pindus.

The botanical relationships with Crete have already been considered, and those with the Cyclades are dealt with below. Floristically Crete, Greece, and the Cyclades are closely related to Asia Minor, and though the Greek flora passes in a depauperated form northwards into Epirus and southern Albania it has received relatively few elements from the north, west, and south. The eastern connexions are phytogeographically far the most important.

2a. **The Cyclades.** This district is composed of a very large number of islands and islets, geographically intermediate between Greece and Asia Minor, and altitudinally nowhere reaching 1,000 m. Geologically they frequently indicate the breaking up of the Aegean continental land and consist chiefly of metamorphic and igneous rocks with Cretaceous dolomites, sandstones, limestones, and conglomerates, and with marine Pliocene deposits only in the southern islands. The invasion of the Aegean Sea was probably not complete till Quaternary times, but the geological, palaeontological, and phytogeographical evidence indicates that the Aegean land mass consisted largely of plains and lake basins, with high mountains few or absent. The climatic conditions are less extreme than in the surrounding mainlands, and, though essentially Mediterranean, are modified by northern exposure. Perennial streams are only found in Naxos and Andros, though springs abound, except where the substratum is limestone. The forests have been almost entirely destroyed and the natural vegetation is now limited to very few localities.

One thousand one hundred and six species are recorded from the Cyclades and the majority of these are also known from Crete or Greece, or from both these districts. One hundred and thirty-three are endemic to the Balkan Peninsular flora as a whole, including 33 which are endemic to the Cyclades alone.

The predominant families in the flora of the Cyclades are:

Gramineae (104), *Liliaceae* (51), *Caryophyllaceae* (55), *Cruciferae* (52), *Leguminosae* (135), *Umbelliferae* (51), *Borraginaceae* (34), *Labiatae* (52), *Scrophulariaceae* (33), and *Compositae* (125). Thirty-nine families represented in the whole Balkan Peninsular flora are absent from that of the Cyclades so far as is known. No family is present in the Balkan Peninsula only in the Cyclades.

Naturally the islands should have a luxuriant tree-growth except where the ridges are too exposed to the Etesian winds. Very few of the peaks pass altitudinally above the hill zone which here, for the most part, is under climatic conditions suitable to the growth of high macchie. Remnants of oak woods occur on Naxos, and associations of *Quercus aegilops* L. are protected on some of the islands. High macchie are now very limited in extent and the main vegetation communities are phrygana and pseudomacchie, which here occur as a biotic climax in the uncultivated areas, and especially on hill slopes. The fertile parts, mainly on schistose substrata, are intensely cultivated, and vineyards and olive groves abound. The limestones are frequently almost barren and have a 'thirsty' appearance. As in Crete the aquatic and marsh flora is poor, since perennial streams only occur in the larger islands.

In spite of the destructive influence of man a detailed botanical survey of this island group would be well worth carrying out. While some of the islands have been fairly well botanized, as Syra, Naxos, and Amorgos, none has been completely investigated, and many of the smaller ones have never been explored botanically. Both floristically and ecologically most interesting results might be expected from a comparative study of the plant life of the different islands and islets.

3. **Thessaly.** This entirely mainland district is most interesting as a geographical link between Greece and the districts of the northern Aegean and for its combination of high mountains and plains. The Central Thessalian plain, or double plain, of Trikkala and Larissa, is entirely surrounded by hills and mountains, and even on the seaward side the Salambria (Peneios) has to break through the barrier in the renowned Vale of Tempe. On the west Thessaly includes much of the high Pindus range, the backbone of the southern part of the Balkan Peninsula. In the north the Khassia range really links the Pindus to Mt. Olympus, with the second highest mountain peak in the Balkan Peninsula and the most beautiful mountain massif I have seen. The Othrys mountains to the south form the boundary with Greece.

Geologically the western mountain masses are largely composed of Cretaceous and Eocene rocks with limestones predominating. Many details regarding the geology are unknown or are in dispute. Much of the eastern part is an extension of the old central core of the Balkan Peninsula whose centre is the Rodope massif.

Climatically the Thessalian lowlands are Mediterranean with a slight trend to transitional conditions. The Pindus and Mt. Olympus certainly have more Central European climatic characteristics, but detailed meteorological records are not available.

One thousand nine hundred and seventy-two species of Phanerogams are known from Thessaly, including 311 Balkan Peninsular endemics, of which 51 are limited to the district. The families represented by most species are: *Gramineae* (145), *Cyperaceae* (45), *Liliaceae* (57), *Caryophyllaceae* (120), *Ranunculaceae* (46), *Cruciferae* (106), *Rosaceae* (68), *Leguminosae* (157), *Umbelliferae* (103), *Borraginaceae* (43), *Labiatae* (114), *Scrophulariaceae* (81), *Rubiaceae* (39), *Campanulaceae* (32), and *Compositae* (271). Sixteen families known from the Balkan Peninsula as a whole are unrecorded from Thessaly. No family is entirely limited in the Balkan Peninsula to this district.

The Thessalian plain has a very uniform flora, mainly Mediterranean in character, though the natural vegetation is either much restricted by cultivation or modified by distance from the sea. The mountain flora is a mixture of Greek high mountain types, Central European species, and a strong endemic element. Beech and conifer woods are very characteristic. These occur on both limestone and serpentine, and the margins of the pine woods are sometimes edged with *Buxus sempervirens* L. In its general vegetation Mt. Olympus is most allied to the Pindus but has a number of endemic species, amongst which the most interesting is *Ramondia heldreichii* Benth. et Hook. f. The mountain has been explored by a number of botanists and was visited in 1926 by the late Dr. Hayek, who informed me that though he found several species new to its flora he discovered none new to science (letter dated 6.7.26).

Floristically Thessaly is conveniently kept as a separate district, though the affinities of its flora with that of South Macedonia are close. To the south the Othrys mountains form a southern barrier to many of the North Aegean and Central Balkan Peninsular lowland and hill species, while the Thessalian plain is a barrier to some montane and high mountain elements. Correspondingly a large number of species characteristic of the Greek lowland flora do not pass northwards of the Othrys mountains. Three hundred and twelve species (excluding the Thessalian endemics) reach their southern limits in Thessaly. The families *Cyperaceae*, *Juncaceae*, *Scrophulariaceae*, *Campanulaceae*, and *Compositae* especially contribute to this total. On the other hand for montane and high mountain species the Pindus range and its subsidiary branches form a route for extended distribution. Species of the Greek high mountain flora, which is so largely composed of Balkan Peninsular endemics, have extended northwards, and species requiring Central

European climatic conditions have extended farther south in the Pindus range than elsewhere in the Balkan Peninsula. We have then, in this district, an interesting example of a mountain chain, the east and west orientated Othrys mountains, being prominent as a floristic barrier, and of another mountain chain, the north and south running Pindus range, being a highway for plant distribution. It should be noted that mountain chains are barriers or highways respectively to species not closely allied to each other and frequently belonging to very different genera and families. On the other hand barriers may be different for different species of the same genus, even when the species are taxonomically closely allied.

The Olympus massif and the Pindus range are the two great mountain groups of Thessaly, and although neither is fully explored botanically it is of interest to note the number of species known from each up to the present. On Mt. Olympus, the second highest mountain in the Balkan Peninsula and only slightly lower than Musalla, 626 species of Phanerogams have been collected. These include 111 Balkan Peninsular endemics, of which 15 are at present known only from Mt. Olympus. The Pindus range has a recorded flora of 1,037 Phanerogams, of which 172 are Balkan Peninsular endemics, including 16 which are not known elsewhere than from this range.

4. **Epirus.** This district, as delimited in the present work, is not, and has not been in modern times, a political unit. It is largely a hilly and mountainous area, though some of the parts near the coast are low and swampy. In the east it includes some of the offshoots of the Pindus range.

Geologically the rocks are mainly from Triassic to middle Tertiary in age, with limestones and serpentines predominating. The western slopes of the Pindus and the area towards the Ionian sea are formed entirely of sedimentary rocks, chiefly nummulitic, and equivalent to palaeogenic flysch.

The meteorological records are meagre but indicate a Mediterranean type of climate for the lowlands, while incomplete and scattered references to climatic conditions in the mountains suggest an approximation to the Central European climate.

One thousand and seventy-four species of Phanerogams are recorded from the district, but this is certainly much too low a figure for the complete flora. The families represented by most species are: *Gramineae* (83), *Caryophyllaceae* (63), *Cruciferae* (59), *Rosaceae* (40), *Leguminosae* (100), *Umbelliferae* (51), *Labiatae* (73), *Scrophulariaceae* (41), and *Compositae* (161). The number of recorded Balkan Peninsular endemics in the flora is 163, and of these 12 are known only from Epirus.

The lowland flora is definitely Mediterranean, typical, and often dense, macchie extending to the foot-hills in places where cultivation and pasturing have not destroyed the natural vegetation. Penetration of the Mediterranean flora can be traced up the Arachthos valley. In the mountains mixed woods and conifer forests naturally predominate, though these have been much destroyed. The high mountain flora is, with few exceptions, of obvious Greek affinities. The flora and vegetation of the whole district are thus essentially of the Greek Mediterranean type, though a number of Central European species extend south in the Pindus range and its offshoots. Epirus is botanically one of the least known districts of the Balkan Peninsula and only tentative suggestions can be made with regard to its phytogeography. When a complete botanical survey has been made it will probably be found that Epirus and northern Greece and southern Albania are most closely allied and either form one botanical district or can be subdivided without reference to the boundaries used in this work.

4a. **Corfu.** This small island district is separated by only a narrow channel from Epirus, of which it is geographically a part. It is formed mainly of Pliocene beds, though other Tertiary and Mesozoic strata outcrop very locally. The climate is typically Mediterranean and the position, sheltered from the east and north, with an absence of high mountains makes it almost subtropical throughout the year.

Nine hundred and eighteen species of Phanerogams are recorded and these include 36 species endemic to the Balkan Peninsula, of which 3 are known only from Corfu. The predominant families in the flora are: *Gramineae* (125), *Cruciferae* (43), *Leguminosae* (96), *Labiatae* (48), *Scrophulariaceae* (32), and *Compositae* (89).

Phrygana and pseudomacchie are now the commonest plant communities, though remains of macchie and woods of *Pinus halepensis* Mill. indicate that the island should naturally be covered with typical Mediterranean woody vegetation. Intensive cultivation and destructive exploitation have left very little of the original vegetation, and probably even the flora has been reduced in species. Nevertheless, Corfu has a considerable phytogeographical importance due to its position and its Mediterranean climate. The extension of the Mediterranean flora and vegetation up the eastern coast of the Adriatic is a well established fact and Corfu is important as a link in tracing the connexion between the Mediterranean flora of Greece and that of southern Dalmatia. This matter is further considered below under the section dealing with the Dalmatian flora. The flora is essentially Greek, and the island is best linked with north-west Greece, Leucas, and Cephalonia as a botanical subdivision of the Mediterranean domain of the Balkan Peninsula.

5. **Albania.** The phytogeographical importance of this district is very great since it forms a link between the Illyrian and Greek floras. It is a very mountainous country and many of its peaks and ranges have not yet been accurately measured. Except in the extreme north the general trend of the mountains is north and south or north-west and south-east. The 'Northern Albanian Alps' cut across almost at right angles, and, from the Shar Planina to the Montenegrin border, the mountain mass and its flora are more nearly related to North Macedonia and Serbia than is any other area near the Adriatic. The coastal parts, except in the south, are low, swampy, and unhealthy. The outcropping rocks are largely Cretaceous and the formation of the main mountain systems appears to have taken place in Middle Tertiary times. The coastal districts have an essentially Mediterranean type of climate, which is, however, modified by greater winter cold than obtains farther south. There are no meteorological figures available for the highlands, but they are noted for the extremity of their winter cold.

Two thousand and fifty-nine species of Phanerogams are known from Albania. Of these 318 species are endemic to the Balkan Peninsula, including 46 which are known only from Albania. The predominant families in the Albanian flora are: *Gramineae* (130), *Cyperaceae* (31), *Liliaceae* (50), *Orchidaceae* (34), *Caryophyllaceae* (124), *Ranunculaceae* (59), *Cruciferae* (96), *Rosaceae* (75), *Leguminosae* (183), *Umbelliferae* (93), *Borraginaceae* (46), *Labiatae* (106), *Scrophulariaceae* (89), *Rubiaceae* (38), *Dipsacaceae* (31), *Campanulaceae* (38), and *Compositae* (265). The relatively high number, 13, of *Pinaceae* is noteworthy. Nineteen families represented in the Balkan Peninsular flora as a whole are not known from Albania. No family occurs only in Albania in the Balkan Peninsula. Of the Balkan Peninsular endemic species a considerable number are Tertiary relicts occurring chiefly in the north-east of this district. Important examples are: *Pinus peuce* Griseb., *Dioscorea balcanica* Košanin (limited to Albania), *Forsythia europaea* Baldacci, *Wulfenia baldaccii* Degen (limited to Albania), and *Ramondia serbica* Panč. The chief centre of endemism certainly appears to be in the north-east, but it must be remembered that the central and south-eastern parts have been very little or not at all explored botanically, while the northern mountains have been visited by several excellent collectors.

In the coastal districts Mediterranean macchie occur, often rich and of a normal composition. Losing some of the less hardy constituents, they spread some distance inland and up the river valleys. Many of the Mediterranean species pass from Greece via coastal Albania and Montenegro to Dalmatia and even Istria, but some apparently

occur in Greece or Corfu or both and in Dalmatia, but miss the intervening coasts in their present form. These are considered with the Dalmatian flora below. Inland the mountains are still often well wooded, for owing to the frequently unsettled political conditions and the lack of transport facilities 'exploitation' is less advanced than in any other of our districts. The montane woods are largely Illyrian in floristic composition. Higher still, and especially inland, the woods resemble very closely those of Central Europe with the common beech or conifers dominant. Excluding the narrow Adriatic coastal parts, and the river valleys which extend inland from them, it is in Albania that the main line or belt of separation between the Illyrian and Greek floras in the west of the Balkan Peninsula must be sought. The evidence clearly points to a belt between the latitudes of Alessio and Tirana. To the north of this the Illyrian flora, at first with a considerable mixture of North Macedonian (especially Scardic) and Serbian species, predominates, while to the south the flora as a whole is Greek in type. We shall see in another section of this work (p. 408) that there is a recognizable break somewhere in this same area between the Alpine and Greek high mountain floras. It must not be thought that this break is absolute, for it is not. Some Illyrian species penetrate south of the suggested transitional area in the Mirdite country, and some Greek high mountain species reach north even to Bosnia. Nevertheless that there is a break is shown by statistics. The causes of this floristic break are probably complex. Cvijić has emphasized (perhaps over-emphasized) the break in continuity of the mountain system of the western parts of the Balkan Peninsula inland from the Drin Gulf. This is just where the floristic transitional region is suggested, and it seems likely that a solution of the problem will be found in a consideration of the geology, geological history, and present orientation of the mountains of this area. The east and west running mountains of northern Albania are now a barrier to the lowland and hill floras—a barrier which can only be passed along a relatively narrow coastal belt. The valleys of the Matya and Drin may be barriers to the high mountain species, but I am doubtful if this is a complete explanation. Unfortunately the full geological history of this area is unknown, and the conclusions of Cvijić, Nopcsa, Vetters, and Nowack are not in complete agreement. Differences of the present climate north and south of the area under consideration do not suffice to account for the floristic differences. The Greek high mountain flora is predominantly composed of endemic species, which are so often taxonomically related to species of the same genus growing at lower altitudes that one is forced to believe that it is mainly of South Balkan Peninsular origin. The species probably arose at different periods and a few have extended

north even to Bosnia. It is possible that these last approximately reached their present northern limits before the Ice Age, which, by lowering the temperature in the north-west of the Balkan Peninsula enabled the Alpine high mountain flora to extend at least some of its species south-eastwards; and that, as far south as the northern Albanian Alps, these have, up to the present, been able to hold their own in competition with the Greek high mountain flora. The abundance of serpentine and dioritic rocks in northern Albania is another unfavourable factor for a southern type of flora, for most frequently in the Balkan Peninsula relatively southern types prefer a calcareous substratum. There is much collecting and field research still to be done in Albania before the phytogeographical problems already evident can be solved. Excepting around Valona there has been little detailed botanical study, though floristically the northern mountains are better known than those of the centre and south-east.[1]

6. **North Macedonia.** This is an entirely inland district and the most central in the Balkan Peninsula. It is practically the drainage basin of the Vardar north of the Nidje Planina, which forms a natural southern boundary. Except for the Vardar valley and a few small, mostly upland, plains it is very mountainous. The mountain chains and masses, are, however, irregularly orientated. Those in the east are geologically related to the old Rodope massif, from which they are separated by the Struma valley, and form a major part of the western transition area of Cvijić. The Shar Planina in the north-west passes westwards into Albania and the south-western mountains are essentially a northern continuation of the Pindus ranges. The climate on the whole approximates to that of Central Europe.

Two thousand one hundred and sixteen species of Phanerogams are recorded from the district. These include 309 species endemic to the Balkan Peninsula, of which 54 are known only from North Macedonia. The predominant families in the flora are: *Gramineae* (111), *Cyperaceae* (46), *Liliaceae* (63), *Caryophyllaceae* (147), *Ranunculaceae* (63), *Cruciferae* (135), *Rosaceae* (61), *Leguminosae* (207), *Umbelliferae* (93), *Borraginaceae* (56), *Labiatae* (117), *Scrophulariaceae* (95), *Rubiaceae* (37), and *Compositae* (259). Twenty families represented in the flora of the Balkan Peninsula as a whole are absent from North Macedonia. No family of the Balkan Peninsular flora is represented solely in this district.

The vegetation is predominantly Central European as opposed to Mediterranean, but endemics and Balkan Peninsular types are important constituents. Some species of the Mediterranean flora penetrate into the district up the Vardar valley, which is one of the best examples

[1] See, however, a recent paper by F. Markgraf in *Fedde Repert.* Beih. xlv. (1927).

in the Balkan Peninsula, of the importance of even a relatively narrow river-valley as a highway for plant migration. There are also numerous enclaves in sheltered localities where the flora is mainly composed of Mediterranean species. The hill, montane, and conifer forests are being rapidly destroyed in many parts, and there are consequently large areas of stony ground and of shiblyak. In the west pseudomacchie of *Buxus sempervirens* L., *Juniperus* spp., and *Quercus macedonica* Griseb. are characteristic and extend over the western boundary into Albania. The high mountain flora is very rich in endemics, and the essentially Balkan Peninsular species *Bruckenthalia spiculifolia* Reichb. is characteristic. To the west, and especially the north-west, both the flora and vegetation are so akin to those of eastern Albania that it is impossible, with the data at present available, to draw any dividing line in this direction. A considerable number of Central European species reach their southern limit in the Balkan Peninsula in North Macedonia. Noteworthy examples are *Drosera anglica* Huds. and *Adoxa moschatellina* L.

6a. **South Macedonia.** The extensive sea-coast, on the Aegean, of this district is a main cause of its floristic peculiarities. It is a hilly and mountainous country with, however, some important plains, notably those of the Struma and the lower course of the Vardar (the Campania). In the west the northern extensions of the Pindus link the mountains of North Macedonia and Albania with the Pindus proper, in the east the main chains run east and west or south-east and north-west, with the valleys opening seawards towards the east. Geologically most of the district belongs to the central core of the Balkan Peninsula and old metamorphic and igneous rocks predominate. The shattering of the Aegean land-mass in geologically recent times severed the direct land connexion with Asia Minor—a connexion still evident in the flora. It must be realized that when the Aegean continent was in existence at its full development South Macedonia was a considerable distance from the sea and more removed from the direct influence of the Mediterranean climate. Its flora, rather than its vegetation, is now, at least in the best known parts, more Mediterranean than Central European, but the evidence is in favour of a relatively recent spread of many of the Mediterranean species. Indeed they may well have spread northwards and inland since the sea invaded the Aegean area. The evidence for the whole of the North Aegean area, and indeed for all the Balkan Peninsula, is in favour of the view that the xerothermic species are still spreading, often owing to the indirect influence of man on the vegetation. The climate is essentially Mediterranean but is not typical, being much colder in winter, especially inland, than in districts to the south.

The known Phanerogamic flora is composed of 2,135 species. Of these 234 are endemic to the Balkan Peninsula, 19 being known only from South Macedonia. The predominant families are: *Gramineae* (148), *Cyperaceae* (32), *Liliaceae* (62), *Orchidaceae* (39), *Caryophyllaceae* (133), *Ranunculaceae* (57), *Cruciferae* (113), *Rosaceae* (62), *Leguminosae* (205), *Umbelliferae* (95), *Borraginaceae* (61), *Labiatae* (122), *Scrophulariaceae* (85), *Rubiaceae* (33), and *Compositae* (258). Nineteen families represented in the flora of the Balkan Peninsula as a whole are absent from South Macedonia. There is no family represented in the Balkan Peninsular flora only in this district.

The Mediterranean macchie are only found in a few sheltered localities in the Khalkidikē peninsula. Pseudomacchie, with *Quercus coccifera* L. frequently dominant, now cover extensive areas, as does also phrygana. Shiblyak occurs inland and at higher altitudes. Most of the low-lying and hill parts are now bare of forest, but in the mountains there are still extensive mixed and coniferous woods. The marsh flora is well developed.

The botanically least known part of the district is in the west, where many of the mountains have never been visited by a trained botanist and none has been fully explored. Without doubt there are still a considerable number of new species to be described from the high mountain flora of this area. Apart from this almost unknown portion South Macedonia has a flora and vegetation closely related to those of Thessaly and Thrace, and the greater part with most of these districts constitutes a North Aegean botanical subdivision.

6b. **Athos Peninsula.** This is geographically and phytogeographically only a small part of South Macedonia. The Athos peak, however, is such a remarkable mountain, and was known to have such an interesting flora, that it was thought worth while to consider its recorded species separately. Except for a narrow isthmus at the Xerxes canal it is entirely surrounded by sea, with the result that it has more continuous and more richly developed macchie than any other part of South Macedonia, excepting perhaps the companion peninsulas of Longos and Cassnadra. The peninsula is mainly composed of schists, conglomerate, and limestones, but the peak is of marble. Except at the higher altitudes the climate is probably Mediterranean.

Seven hundred and twenty-three species of Phanerogams are known from the Athos Peninsula, but there are probably many common species which have not been collected. The Balkan Peninsular endemics number 74, and of these 16 are limited to the Athos Peninsula, most of them to the mountain. The most important families are: *Gramineae* (39), *Caryophyllaceae* (31), *Cruciferae* (33), *Leguminosae* (81), *Umbelliferae* (36), *Labiatae* (36), and *Compositae* (82). Forty-four families of

the Balkan Peninsular flora are not yet recorded, and no family of the flora is known only from the Athos Peninsula.

The following species, in addition to the endemics, are known for certain in the Balkan Peninsula only from the Athos Peninsula: *Ruscus hypophyllum* L., *Ranunculus trilobus* Desf., *Alyssum cephalotes* Boiss., *Saxifraga sancta* Griseb., *Heracleum humile* S. et S., and *Plantago squarrosa* Murr. A number of species are known only from the Athos Peninsula and South or North and South Macedonia, while several are endemic to the Rodope massif and the Athos Peninsula. *Hypericum athoum* Boiss. et Orph. is recorded only from Athos and the Thracian Islands, while those species which appear in their present distribution 'to jump' the Aegean sea are given below in a later paragraph.

The vegetation of Athos shows very clear altitudinal zonation and can best be briefly considered on this basis. In the lower parts the macchie predominate and are well developed. Above is a belt of mixed wood still essentially Mediterranean in floristic composition. A zone of oaks is succeeded by *Pinus* and *Abies* zones, while the peak is above the forest zones.

Athos has been visited by various botanists but the exploration of the Peninsula and peak is far from completed. Thus the taxonomy of the *Abies* is not yet settled, and will not be till large collections and field observations have been made.

7. **Thrace.** The particular interest of this district is that it is the most south-eastern of our area and is the one nearest to Asia Minor in the existing configuration of the land. It is one of the least mountainous districts of the Balkan Peninsula and the only ranges of importance are the Tekir Dagh in the south and the Strandja in the east. The greater part of the district is drained by the river Maritsa and its tributary the Ergene. The greater part of Thrace is based on a part of the old Archaean central core of the Balkan Peninsula. Younger rocks cover much of the lowlands and margins. Previous to the formation of the Aegean Sea, Thrace must have been completely joined to Asia Minor in the Aegean and Marmara areas. The climate is essentially Mediterranean, especially in the west, but is much modified by proximity to the Black Sea. The winter is colder, the summer less hot, and the summer drought less extreme than in typical Mediterranean districts.

Two thousand one hundred and forty-eight species of Phanerogams are known from Thrace. One hundred and thirty-six of these are Balkan Peninsular endemics, of which 30 are known only from Thrace. The phytogeographical importance of Thrace as a link between Asia and Europe is dealt with on pp. 373 seq., where the general Oriental affinities of the Balkan Peninsular flora are considered. The predominant families in the Thracian flora are: *Gramineae* (158), *Cyperaceae*

(48), *Liliaceae* (67), *Orchidaceae* (44), *Chenopodiaceae* (35), *Caryophyllaceae* (105), *Ranunculaceae* (65), *Cruciferae* (102), *Rosaceae* (46), *Leguminosae* (241), *Euphorbiaceae* (33), *Umbelliferae* (98), *Borraginaceae* (62), *Labiatae* (115), *Scrophulariaceae* (71), *Rubiaceae* (42), and *Compositae* (241). Sixteen families of the whole Balkan Peninsular flora are unrecorded from Thrace and no family is known only from this district.

Near the coast there are small areas of macchie, often of a depauperate type. Pseudomacchie and shiblyak are very characteristic vegetational communities. The marsh and aquatic floras are well developed. Except in the Strandja and its extension into the Belgrade forest, there is little forest now remaining. Unfortunately the north-eastern part of the district is the least known. In all probability there is here a Pontic-Caucasian type of flora and vegetation. The northern part of the Strandja, which passes over the frontier into South Bulgaria, certainly has this, and the Thracian (now Turkish) part of this range is likely to prove one of the most interesting of the hitherto botanically unknown parts of the Balkan Peninsula.

7a. **Thracian Islands.** The three islands of Samothrace, Imbros, and Lemnos have been considered as a small separate sub-district. The first has been visited by Dr. Degen (see *Oesterr. Bot. Zeitschr.* xli. 301, 329, 1891), but from the other two only a few casually collected specimens and isolated observations are available. Geologically and geographically the islands form an outlying group to the Aegean coast of Thrace. The climate is essentially Mediterranean but frequent strong winds are a modifying factor. A total of only 142 species of Phanerogams are recorded from the three islands. This is probably not more than a fifth to a tenth of the total, and it is therefore inadvisable to draw any detailed conclusions. Indeed the main result obtained by treating this sub-district separately has been to emphasize the need for a floristic and ecological investigation of the group. A greater proportion of the known species than would be expected from a consideration of the geographical position alone have a southern distribution.

The chief vegetational communities appear to be macchie, pseudomacchie, and phrygana in the lowland and hill zones. The pseudomacchia goes up to 1,000 m. in the steep island of Samothrace, and above this altitude to the peak, 1,600 m., is replaced by low open brushwood and rock associations. Forest is rare or absent.

The flora of the Aegean districts. All of the districts which border on or are in the Aegean have been considered above, and it will be convenient to deal with a few of the general conclusions reached. The existence till the end of Tertiary times of an Aegean land-mass linking Europe and Asia has been frequently mentioned. The former exis-

tence of this explains the close affinities of the Cretan and Greek floras with that of Asia Minor. It must also be noted that an arm of the Pontic Sea extended across the northern part of this land mass in late Tertiary times and for a period must have formed a partial barrier to the north-west spread of Oriental species into the Balkan Peninsula. There is a considerable number of species which have a north and south distribution in the Aegean area. It is most instructive to consider those species which, within the area considered in this work, occur in one or more of the districts Crete, Greece, and the Cyclades and then appear to jump to one or other of the North Aegean districts. These are partly relicts of a more continuous distribution when the Aegean was a land area, and partly results of a more recent northward dispersal extending the range of Mediterranean species. The table, pp. 332–7, illustrates the chief kinds of discontinuous distributions across the Aegean from north to south, and also gives the general distribution of each species named.

The list is not exhaustive but it includes examples of the different types of the general north and south distribution in the Aegean area and the more obvious and important instances. It is sufficient to prove the existence of a route or routes of dispersal resulting in a north and south distribution, which, it must be noted, is not continued south to or from the African continent.

A general comparison of the plant life of the North Aegean districts with that of the western districts of the Balkan Peninsula reveals the fact that typical Mediterranean species play a much more important rôle in the latter than in the former and penetrate much farther north, even to Istria. A similar phenomenon is noted when the two sides of the Adriatic are botanically compared, the eastern coasts having the richer floras and better developed vegetational communities. Comparisons between the two sides of the Italian and Iberian Peninsulas indicate that the western are also the more favoured climatically although, owing to physiographic factors, there are many detailed differences between these land masses and the Balkan Peninsula.

8. **North Bulgaria.** This large district is bounded on the south by the Stara Planina (Balkan range), on the east by the Black Sea, on the west chiefly by the old political frontier, and on the north by the Danube. Excluding the unnatural south-west prolongation it is practically the southern part of the Danube basin. The upper course of the Struma is included, but south of Kyustendil it would be better to consider it as a northern extension of South Macedonia. I was in this valley for a few hours in 1926 and saw just enough of its flora to convince me that it is of a more Mediterranean composition than that of North Bulgaria proper. The south-western part of the district is

DISTRIBUTION OF CERTAIN SPECIES OF THE AEGEAN AREA

	Crete	Greece	Cyclades	Corfu	Albania	S. Macedonia	Athos	Thrace	Thracian Islands	S. Bulgaria	Rodopes	Dalmatia	S. Croatia	Istria	E. N. Temperate	Medit. Regional	Medit. Basin	S. European	E. Medit. Basin	Oriental	Pontic	Caucasian	Balk. Peninsular	Endemic
Pinus pinea L.	×	×	×	×	..	..	×	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..
Bromus macrostachys Desf.	×	×	..	..	..	×	..	×	..	..	..	×	..	..	..	×	..	..	..	..	..	×	..	..
Gastridium scabrum Presl	×	×	..	..	..	..	..	×	..	..	..	..	..	..	..	×	..	..	..	..	..	×	..	..
Weingaertneria articulata Aschers. et Graebn.	×	×	×	×	..	..	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..
Juncus pygmaeus Rich.	..	..	×	..	..	..	..	×	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..
Allium cyrillii Ten.	..	×	..	..	..	..	..	×	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..
A. staticiforme S. et S.	×	..	×	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
Asparagus aphyllus L..	×	×	×	..	..	×	×	×	..	..	..	..	..	..	..	×	×	..	..	..	..	..	..	..
Hyacinthus ciliatus Cyr.	..	×	..	..	..	×	..	×	..	..	..	..	..	..	..	×	..	..	..	..	..	×	..	..
H. trifoliatus Ten.	..	×	..	..	..	..	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..
Crocus olivieri Gay	×	×	×	..	..	×	..	×	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..
C. tournefortii Gay	..	×	×	..	..	..	..	×	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	×
Iris sisyrinchium L.	×	×	×	×	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Romulea parviflora Bubani	×	×	..	..	..	..	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..
R. ramiflora Ten.	×	×	..	..	×	..	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..
Cephalanthera cucullata Boiss. et Heldr.	×	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	×	..	×	..	..
Ophrys oestrifera Bieb.	×	×	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	×	..	×	..	..
O. speculum Link	×	×	..	..	..	..	..	×	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..
O. tenthredinifera Willd.	×	×	×	..	..	..	..	×	..	..	..	×	..	..	..	..	×	..	..	..	..	..	..	..
Orchis saccata Ten.	×	×	..	..	..	..	..	×	..	..	..	..	×	×	..	..	×	..	..	..	..	..	..	..
Spiranthes aestivalis Rich.	..	×	..	..	..	..	..	×	..	..	..	..	×	×	..	..	..	..	..	..	..	..	..	..

Cytinus hypocistis L.	×	×	×	×	..	..	..	×	..	..	..	×	..	×	..	..	..	..	..	..	..	..	..	..	..
Polygonum equisetiforme S. et S.	×	..	×	..	..	..	..	×	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..
Petrosimonia brachiata Bunge	..	×	..	..	..	×	..	×	..	×	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..
Arenaria graeca Hal.	..	×	..	..	..	..	..	..	×	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..
Paronychia macrosepala Boiss.	×	×	×	..	..	..	..	..	×	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..
Saponaria graeca Boiss.	..	×	..	×	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
Silene behen L.	×	×	×	..	..	..	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..
S. bellidifolia Jacq.	×	×	..	×	×	..	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..
S. discolor S. et S.	..	..	×	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..
S. fabaria S. et S.	..	×	..	..	..	×	×	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..
S. longipetala Vent.	..	×	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	×	..	×	..	..	..
S. pendula[1] L.	×	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	×	..	..	..
Spergularia diandra Heldr. et Sart.	×	×	×	..	×	×	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	×	..	..	..
Adonis cupaniana Guss.	×	×	×	..	..	×	..	×	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..
Ranunculus heldreichianus Jord.	..	×	..	..	..	×	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
Papaver pinnatifidum Moris	..	×	..	..	..	..	..	×	..	..	×	..	..	..	..	..	×	..	..	..	..	..	..	..	..
Alyssum foliosum[2] Bory et Chaub.	×	×	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..
A. smyrnaeum C. A. Mey.	..	×	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..
A. suffrutescens Hal.	..	×	..	×	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..
A. umbellatum[2] Desf.	..	..	×	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..
Brassica cretica L.	×	×	×	×	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..
Lepidium spinosum L.	×	×	×	..	..	×	×	×	..	×	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..
Malcolmia angulifolia[2] Boiss. et Orph.	×	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	×
Anthyllis tetraphylla L.	×	×	×	..	..	..	×	×	..	..	..	×	..	..	..	..	×	..	..	..	..	..	..	..	..
Coronilla parviflora Willd.	×	×	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..
Cytisus spinescens[3] Presl	..	×	..	..	..	..	×	..	..	..	..	×	×	..	..	..	..	..	..	..	..	..	..	..	..
Dorycnium rectum Ser.	×	×	..	×	..	..	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..
Hippocrepis biflora Spreng.	..	×	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	×	..	..	..
Lotus coimbrensis Willd.	×	×	×	..	..	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..
L. edulis L.	×	×	×	×	..	..	×	..	..	..	..	×	..	..	..	..	×	..	..	..	..	..	..	..	..
Lupinus pilosus Murr.	..	×	..	×	..	..	..	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..

[1] Also from Serbia. [2] Also from N. Macedonia. [3] Italian.

DISTRIBUTION OF CERTAIN SPECIES OF THE AEGEAN SEA (*continued*)

	Crete	*Greece*	*Cyclades*	*Corfu*	*Albania*	*S. Macedonia*	*Athos*	*Thrace*	*Thracian Islands*	*S. Bulgaria*	*Rodopes*	*Dalmatia*	*S. Croatia*	*Istria*	*E. N. Temperate*	*Medit. Regional*	*Medit. Basin*	*S. European*	*E. Medit. Basin*	*Oriental*	*Pontic*	*Caucasian*	*Balk. Peninsular*	*Endemic*
Medicago ciliaris Willd.	..	×	..	×	..	..	..	×	..	..	..	×	..	..	..	×	..	..	..	..	..	..	..	..
M. globosa Presl	..	×	×	..	..	×	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..
M. murex Willd.	×	×	×	..	..	..	×	×	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..
Ononis mitissima L.	×	×	..	..	..	..	..	×	..	..	..	×	..	..	..	×	..	..	..	..	..	..	..	..
O. pubescens L.	×	×	×	..	..	×	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..
Ornithopus pinnatus Druce	..	×	×	..	..	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..
Scorpiurus sulcata L.	×	×	×	×	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Trifolium formosum Urv.	×	×	×	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..
T. radiosum Wahlenb.	..	×	..	..	..	×	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
T. spumosum L.	×	×	×	..	..	×	..	×	..	..	..	..	..	..	..	×	..	..	×	..	..	..	..	..
Trigonella caerulescens Hal.	..	×	×	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..
T. foenum-graecum L.	×	×	..	..	..	×	..	×	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..
T. spruneriana Boiss.	×	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Erodium laciniatum Willd.	×	×	×	..	..	..	..	×	..	..	..	..	..	..	..	×	..	..	..	..	..	×	..	..
E. romanum L'Hér.	..	×	×	..	..	..	..	×	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..
Ruta buxbaumii Poir.	×	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
R. montana L.	..	×	..	..	..	..	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..
Euphorbia biglandulosa Desf.	×	×	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	×	..	..	×	..	..
E. cybirensis Boiss.	×	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..
E. sibthorpii [1] Boiss.	..	×	×	..	..	×	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..
Lavatera unguiculata [1] Desf.	×	×	×	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..
Malope malacoides L.	×	×	..	×	..	..	..	×	..	..	..	×	..	..	..	..	×	..	..	..	..	×	..	..

[1] Also from N. Macedonia.

Tamarix tetrandra Pall.	×	×	..	..	..	×	..	×	..	×	..	..	..	..	..	..	..	..	..	×	..	×	..	..
Cistus parviflorus Lam.	×	×	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..
Daphne collina Sm.	×	×	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..
Thymelaea hirsuta Endl.	×	×	×	..	..	..	..	×	..	..	..	×	..	..	..	×	..	..	..	..	..	..	..	..
T. tartonraira All.	..	×	×	..	..	..	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..
Bupleurum fontanesii Guss.	..	×	..	..	..	×	..	×	..	×	..	..	..	..	..	..	×	..	..	..	..	..	..	..
B. trichopodum Boiss. et Sprun.	..	×	×	..	..	×	..	×	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..
Hippomarathrum cristatum[1] Boiss.	×	×	..	..	..	×	×	×	..	×	×	..	..	..	..	..	×	..	..	..	..	..	..	..
Johrenia distans Hal.	..	×	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
Orlaya pumila Hal.	×	×	×	×	..	×	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..
Peucedanum obtusifolium S. et S.	..	×	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..
Cyclamen indicum L.	×	×	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..
Limonium sinuatum Mill.	×	×	×	..	..	..	×	×	×	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..
L. virgatum Fourr.	×	×	×	..	×	×	..	×	..	..	..	×	..	..	..	..	×	..	..	..	..	..	..	..
Styrax officinalis L.	×	×	×	..	..	..	..	×	..	..	..	×	..	..	..	..	×	..	..	..	..	..	..	..
Convolvulus pentapetaloides L.	..	×	×	..	..	×	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..
Alkanna sieberi DC.	×	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
Echium elegans Lehm.	×	×	×	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..
E. sericeum Vahl	×	×	×	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..
Myosotis litoralis Stev.	..	×	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..
Lamium moschatum L.	..	×	×	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..
Micromeria nervosa Benth.	×	×	×	×	..	..	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..
Scutellaria rupestris Boiss. et Heldr.	..	×	..	..	..	..	..	×	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	×
Sideritis lanata L.	..	..	×	..	..	×	..	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..
S. remota Urv.	..	×	..	..	..	×	..	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..
S. theezans Boiss. et Heldr.	..	×	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
Stachys cretica L.	×	×	×	..	×	×	..	..	×	..	..	..	..	..	..	..	..	..	×	..	..	×	..	..
S. tournefortii Poir.	×	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
Thymbra spicata L.	×	×	×	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..
Hyoscyamus reticulatus L.	×	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	×	..	×	..	..
Veronica thymifolia S. et S.	×	×	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
Globularia alypum L.	×	×	×	..	..	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..

[1] Also from N. Macedonia.

DISTRIBUTION OF CERTAIN SPECIES OF THE AEGEAN AREA (*continued*)

	Crete	*Greece*	*Cyclades*	*Corfu*	*Albania*	*S. Macedonia*	*Athos*	*Thrace*	*Thracian Islands*	*S. Bulgaria*	*Rodopes*	*Dalmatia*	*S. Croatia*	*Istria*	*E. N. Temperate*	*Medit. Regional*	*Medit. Basin*	*S. European*	*E. Medit. Basin*	*Oriental*	*Pontic*	*Caucasian*	*Balk. Peninsular*	*Endemic*
Plantago cretica L.	×	..	×	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..
Galium incanum [1] S. et S.	×	×	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..
Rubia olivieri Rich.	×	×	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Vaillantia hispida L.	×	×	×	..	..	..	..	×	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..
Lonicera helenica Orph.	..	×	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
Kentranthus calcitrapa L.	×	×	×	..	..	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..
Fedia cornucopiae L.	×	×	..	..	×	×	..	×	..	..	..	×	..	..	..	..	×	..	..	..	..	..	..	..
Valerianella hirsutissima Link	..	×	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..
V. obtusiloba Boiss.	×	×	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
V. vesicaria Moench	×	×	..	..	..	..	..	×	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..
Scabiosa sicula L.	×	..	..	..	..	×	..	×	..	×	×	..	..	..	..	×	..	..	..	..	..	..	..	..
Symphyandra cretica A. DC.	×	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
Anacyclus clavatus Pers.	..	×	..	..	..	..	..	×	..	..	..	×	..	..	..	..	×	..	..	..	..	..	..	..
Andryala dentata S. et S.	..	×	×	..	..	..	×	×	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..
Anthemis auriculata Boiss.	..	×	×	..	..	..	×	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..
A. cretica Nyman	×	×	×	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..
A. panachaica Hal.	..	×	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
A. tomentosa L.	..	×	..	×	..	×	..	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..
Carduus acicularis Bert.	..	×	..	..	..	..	..	×	..	..	..	×	..	×	..	..	..	×	..	..	..	..	..	..
Carthamus ambiguus Heldr.	..	×	×	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
Catananche lutea L.	×	×	..	..	..	×	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..
Centaurea spinosa L.	×	×	×	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..

[1] Also from Epirus.

Chamaepeuce mutica DC.	×	×	×	×	..	..	×	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..
Chondrilla ramosissima S. et S.	×	×	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
Chrysanthemum myconis L.	×	×	..	×	..	×	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..
Cichorium pumilum Jacq.	×	×	×	..	..	..	..	×	..	..	..	×	..	..	..	..	×	..	..	..	..	..	..	..
Crepis aspera L.	×	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..
C. divaricata Boiss. et Heldr.	×	×	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
C. reuteriana Boiss.	..	×	..	×	..	..	..	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..
Evax exigua DC.	..	×	..	..	..	..	..	×	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..
Helichrysum siculum Boiss.	×	×	×	×	..	..	..	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..
Jurinea consanguinea DC.	..	×	..	..	..	..	..	×	..	..	×	..	..	..	..	..	..	..	×	..	..	..	..	..
Pulicaria sicula [1] Moris	×	×	..	..	×	..	..	×	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..
Scolymus grandiflorus Desf.	..	×	..	..	..	..	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..
Scorzonera calcitrapifolia Vahl	..	×	..	..	..	×	..	..	..	×	..	..	..	..	..	..	..	..	..	×	..	..	..	..
S. lanata Bieb.	..	×	..	..	..	×	..	×	..	×	..	..	..	..	..	..	..	..	..	×	..	×	..	..

[1] Also from Epirus.

mountainous with some high plains—such as that of Sofia. Apart from the Struma valley there is a general gradual slope down to the Danube from the high range of the Stara Planina. This last is largely composed of rocks of Carboniferous and Cretaceous age with igneous intrusions and crystalline schists. In the 'Balkan tableland' the predominant rocks are Cretaceous limestones and marls, often covered with loess, alluvium, and various Quaternary deposits. The climate is of the continental Central European type with hot summers and often very cold winters, the rainfall being distributed throughout the year, but heaviest in summer.

Two thousand five hundred species of Phanerogams are known from the area and this is the highest figure for any district except Greece. There are 255 Balkan Peninsular endemics, of which 56 are known only from this district. The predominant families are: *Gramineae* (167), *Cyperaceae* (74), *Liliaceae* (91), *Orchidaceae* (39), *Chenopodiaceae* (31), *Caryophyllaceae* (142), *Ranunculaceae* (79), *Cruciferae* (119), *Rosaceae* (93), *Leguminosae* (191), *Umbelliferae* (128), *Borraginaceae* (63), *Labiatae* (130), *Scrophulariaceae* (116), *Rubiaceae* (45), *Campanulaceae* (39), and *Compositae* (326). Eighteen families of the whole Balkan Peninsular flora are not known from this district. No family is known only from North Bulgaria.

The plains are mostly highly cultivated, while many of the hills and mountains, which were formerly densely wooded, are now covered with shiblyak or are stony or grassy slopes. In the less accessible places oak, mixed wood, beech, and conifer forests still occur, though the last especially are getting rarer. There are considerable tracts of sandy ground and even dunes with a characteristic arenaceous vegetation. Towards the north-east there is a tendency to steppe development and a gradual transition to the vegetation of the Dobruja. The marsh and aquatic vegetation is well developed.

The flora is essentially Central European in the broad sense, and belongs to the Pontic section. There is a noticeable Caucasian and Oriental element also present, especially in the east. For example, *Fagus orientalis* Lipsky is now known from north of Varna. There is no doubt that most of the upper Struma valley must be considered separately from the rest of North Bulgaria and preferably with South Macedonia. When this is done the district left is a fair unit, so far as can be judged from available data. The Stara Planina requires further detailed investigations on the distribution of its species, more especially in the central and eastern parts. Jordanoff (in *God. na Sofijskii Universit.* xx. 1, 1924) has shown the close relationship between the high mountain flora of the western part and that of the Carpathians—a relationship apparently closer than that existing with the central

parts of the Stara Planina (Kalofer Balkan, &c.). A full explanation of the last fact has still to be found. The North Bulgarian plain, with a general slope to the Danube, is an older land than the Roumanian and Hungarian plains, at least in part. Its flora is richer than these, and a considerable number of species have not spread beyond the Danube, including a fair number which are known from the South Russian steppes, while some have reached only to the Banat.

North Bulgaria is relatively well explored floristically, though it is a large district and no part can be said to be exhausted. In detailed ecology, as the term is understood in Central and Western Europe, practically nothing has been done since the published work of Adamović.

8a. **South Bulgaria.** This is a smaller district protected by the Stara Planina and the Rodopes. Practically it is the basin of the upper Maritsa, excluding the tributaries of this river which are in the mountains. Most of the area is flat or undulating plain, but the Strandja Planina in the east reaches over the Bulgarian boundary from Thrace. The lowland is largely covered with Quaternary deposits yielding a rich soil. The climate is warmer and less wet than that of North Bulgaria, and shows some Mediterranean characteristics. It is possible that the extreme south-eastern part may have ultimately to be separated on meteorological grounds as it certainly should on phytogeographical.

One thousand seven hundred and thirty-three species of Phanerogams are recorded from the district. These include 164 Balkan Peninsular endemics, of which 28 are known only from South Bulgaria at present. The dominant families in the flora are: *Gramineae* (134), *Cyperaceae* (48), *Liliaceae* (79), *Caryophyllaceae* (91), *Ranunculaceae* (57), *Cruciferae* (87), *Rosaceae* (41), *Leguminosae* (158), *Umbelliferae* (79), *Borraginaceae* (55), *Labiatae* (104), *Scrophulariaceae* (73), and *Compositae* (198). Twenty-seven families of the Balkan Peninsular flora are not represented in the district, and no family occurs only here.

Except in the east a very large proportion of the ground is cultivated and yields rich crops of tobacco, rice, &c. There is little forest left outside the Strandja, but pseudomacchie and shiblyak occur, sometimes in quantity. There are now extensive areas of 'grassland' of a steppe-like character and often dominated either by *Chrysopogon gryllus* or by annual herbs, especially *Leguminosae* and *Gramineae*. The flora and the vegetation of the northern part of the Strandja Planina are so very distinct from that of the rest of Bulgaria that there is little doubt that this area must be placed in a distinct subdivision. There is here a fine development of forest of the composition characteristic of the northern parts of Asia Minor and of the western Caucasus. It is very probable that we have here, and in parts of the Rodopes, the

nearest existing approach to the vegetation which covered at least much of the Balkan Peninsula in Tertiary times.

8b. **The Rodope Massif.** This is entirely a mountainous district, with the highest peak, Musalla, in the Balkan Peninsula. It includes the most definite part of the old Archaean core and must have been dry land for long geological periods. There is no trace of marine rocks of Tertiary age so far as I have observed or been able to find in the literature available. Igneous and metamorphic rocks of many kinds, including modified and crystalline limestones, form the great bulk of the Rodope massif in the broad sense in which the term is used here. The Rodopes are less important as a watershed than the Stara Planina. The Struma in the west actually rises in the Vitoša. The Mesta (Kara Su) is with its tributaries essentially a river of the southern Rodopes. To the north the Isker and its tributaries, and to the east the Maritsa and its tributaries, especially the Arda, are the principal rivers. The streams frequently run in very deep and steep-sided gorges. They are usually swift flowing and shallow. The climatic conditions vary greatly according to altitude and orientation. In the higher parts there is a close approximation to the Alpine type of climate, with a heavy winter snowfall, patches of which remain through the summer. In the north-western parts (Rila) the area is the most moist of any I have visited in the Balkan Peninsula, although the total yearly rainfall is much less than in the north-west of the Peninsula.

The known Phanerogamic flora consists of 1,847 species, including 286 Balkan Peninsular endemics, of which 47 are known only from the Rodopes. The dominant families are: *Gramineae* (107), *Liliaceae* (55), *Orchidaceae* (31), *Caryophyllaceae* (132), *Ranunculaceae* (51), *Cruciferae* (91), *Rosaceae* (81), *Leguminosae* (134), *Umbelliferae* (81), *Borraginaceae* (46), *Labiatae* (103), *Scrophulariaceae* (95), *Rubiaceae* (33), *Campanulaceae* (42), and *Compositae* (239). Thirty-three families of the Balkan Peninsular flora are absent from this district and no family is entirely restricted to it.

The vegetation shows a great range of plant communities, owing to the altitudes reached. The southern slopes have some pseudomacchie, and the flora has a strong Mediterranean element in it. There are still fine forests in the Rodopes, indeed in the Rila area the finest in the Balkan Peninsula and perhaps the finest in Europe are in an absolutely primitive condition. Conifers and beech predominate above, with oaks on the lower slopes. Shiblyak is frequent but is less characteristically developed, on the whole, than in most other of the central parts of the Balkan Peninsula. The aquatic vegetation is not rich, but the rock and high mountain associations are the richest in the Peninsula and abound in endemic species.

Armeria rumelica Boiss.

This species has a wide distribution in stony and rocky habitats through the central parts of the Balkan Peninsula. It varies in the colour of its flowers from pink to white, and somewhat in the breadth of its leaves. The plants figured are Bulgarian specimens; that on the right has pink flowers, and that on the left has white flowers and somewhat narrower leaves. The species is doubtfully distinct from the Italian *A. macropoda* Boiss.

Matricaria tenuifolia Tuzson (*M. trichophylla* Boiss.)

This plant, grown from fruit collected above the Rila Monastery, Bulgaria, is over 1 m. in height and its finely cut foliage gives it a very graceful appearance.

The Rodopes are very incompletely explored botanically [1] and it is impossible to suggest a satisfactory subdivision of the district. In 1926 we found some evidence (as the occurrence of *Fagus orientalis* Lipsky) that the south-eastern portion shows relationship with the Strandja. While the flora shows examples of immigration (in the sense of extension of area) of species from Asia Minor, from the Aegean area, and from the Carpathians and Alps, it is clear that it has been a most important refuge for relict types and also a centre of species formation and dispersal.

9. **The Dobruja.** This is the most north-eastern of our districts and, via southern Bessarabia, links the Balkan Peninsula with southern Russia. It is mainly a flat undulating area, excepting the Babadagh, a group of hills in the north. The Danube with its marshes, especially in the delta, is an important feature. Loess and alluvium cover most of the Mesozoic and Tertiary deposits. The Babadagh is, however, a mass of old rocks, which projects above the loess covering. It is probable that this mass is connected geologically with the Crimea and Caucasus, but there is practically no botanical evidence of such a direct connexion since Mesozoic times. In climate the Dobruja shows a close relationship with South Russia, with considerable extremes of temperature between summer and winter and a relatively low rainfall.

One thousand two hundred and ninety-eight species of Phanerogams are known from the district, including 27 species endemic to the Balkan Peninsula, of which 5 are known only from the Dobruja. The predominant families are: *Gramineae* (75), *Liliaceae* (44), *Chenopodiaceae* (40), *Caryophyllaceae* (75), *Ranunculaceae* (36), *Cruciferae* (81), *Rosaceae* (38), *Leguminosae* (99), *Umbelliferae* (65), *Borraginaceae* (38), *Labiatae* (63), *Scrophulariaceae* (43), and *Compositae* (176).

The lowlands are highly cultivated, but sufficient of the wild flora remains to show that 'grassland' of steppe type is the natural vegetation. Sandy areas and dunes are of frequent occurrence. Shiblyak of *Syringa vulgaris* L., *Fraxinus ornus* L., and low oaks is found locally. The Babadagh has mixed forests largely of *Quercus* spp. and some beech (probably *Fagus orientalis* Lipsky).[2] The aquatic flora is strongly developed in the Danube delta. Phytogeographically the interest of the Dobruja lies in the number of species which through it reach the Balkan Peninsula from the northern parts of the Black Sea area. Some of these have extended widely into the Peninsula, others have reached only to North Bulgaria or are even limited to the Dobruja. On the other hand there are a fair number of southern (Mediterranean) types

[1] For the best recent account see B. Stefanoff, *Proizchoždenie i razvitie na vegetacionnite tipove ve Rodopite* (Origin and development of the vegetation types in the Rodopes, Sofia, 1927).

[2] See Grinţescu in *Bul. Grăd. Botan. Cluj*, vii. 57 (1927).

which reach through the Balkan Peninsula to the Dobruja, where some have their northern limit. Examples of Mediterranean plants in the Dobruja are: *Polypogon monspeliensis* Desf., *Celtis australis* L., *Ficus carica* L., *Medicago marina* L., *Geranium asphodeloides* Burm., *Peganum harmala* L., *Frankenia pulverulenta* L., *Physocaulis nodosus* Koch, *Pimpinella tragium* Vill., *Fraxinus ornus* L., *Cynanchum acutum* L., *Periploca graeca* L., *Convolvulus cantabrica* L., *Stachys maritima* L., *Ecballium elaterium* Rich., *Micropus erectus* L., and *Scolymus hispanicus* L.

10. **Serbia.** This large district is the most inland of all our divisions. Its drainage is entirely into the Danube, mainly by means of the important tributary of the Morava. The northern part is relatively low, and large areas are sometimes subjected to considerable flooding, as in 1926. To the east, south, and west there are many mountain groups of varied orientation. The eastern part of Serbia is the edge and one of the transitional areas of the old Archaean core, while towards the west this joins on to a folded belt which is a portion of the folded mountain system of the western Balkan Peninsula. It follows that rocks of many ages and of very varied composition occur, and there is a considerable range of soil types—probably a greater range than in any other of our districts. Climatically Serbia comes within the Central European domain. The winter is cold with frequent falls of snow, and the summer usually hot and, in the lowlands, often even oppressive.

The Phanerogamic flora consists of 2,470 species, including 180 Balkan Peninsular endemics, of which 7 are limited to Serbia. The predominant families are: *Gramineae* (169), *Cyperaceae* (83), *Liliaceae* (75), *Orchidaceae* (47), *Caryophyllaceae* (132), *Ranunculaceae* (87), *Cruciferae* (124), *Rosaceae* (104), *Leguminosae* (179), *Euphorbiaceae* (34), *Umbelliferae* (127), *Borraginaceae* (45), *Labiatae* (125), *Scrophulariaceae* (107), *Rubiaceae* (40), *Campanulaceae* (45), and *Compositae* (298). Twenty-two families of the Balkan Peninsular flora are absent from Serbia, and no family is represented in this district only.

Forests have been largely destroyed but still occur in the western mountains and locally in all higher parts. There is the normal altitudinal zonation of the central parts of the Balkan Peninsula with oaks below, mixed woods, beech, and conifers above. Shiblyak is the most widely spread vegetational type and occupies much ground formerly covered with forest. The high mountain vegetation is best developed in the south-west. Aquatic species and communities are abundant in the marshy ground of the river valleys and along the Danube. There are tracts of sandy ground even with dunes. Floristically the Central European element dominates, but Pontic species and Mediterranean

enclaves are frequent. The latter occur in warm and sheltered lowland spots. The flora of the eastern parts is naturally very closely related to that of western North Bulgaria, and that of the west to the Bosnian flora with a considerable number of Illyrian species. It is impossible at present to mark any sharp line of demarcation—indeed none probably exists—but a north to south line of division between eastern and western Serbia may be provisionally accepted along the valley of the Morava.

10a. **The Sandjak of Novi Pazar.** This area, interpolated between Serbia, Bosnia, Montenegro, Albania, and North Macedonia, is botanically the least known of all our districts. It is hilly and mountainous and is drained by the upper courses of various rivers, of which the Ibar is the chief. Geologically it mainly belongs to the inner edge of the folded system of the western parts of the Balkan Peninsula but in the south-east is partly transitional. Limestones and serpentines are very frequent. The climate is said to be very severe.

Only 228 species are known to me from this district—probably only one-tenth of the flora. There are many more in the herbaria at Belgrade and Vienna but they have never been worked out for publication. There is, therefore, little to be said regarding the flora and vegetation, except to urge the need of botanical research in the district and the working out of collections already made. The meagre evidence available suggests that the southern part is botanically akin to North Macedonia and probably the greater portion should be merged in this district. A very large proportion of the forest has been destroyed and karst conditions are reported for many of the mountains. Oaks, beech, and conifers, however, indicate a normal altitudinal zonation.

11. **Montenegro.** This relatively small area practically consists of a narrow lowland coastal strip and a mountain hinterland. Climatic and other conditions therefore range from those of the Mediterranean to those of high mountains, practically of an 'Alpine' nature. Excepting for the Morača, with its tributary the Zeta, draining into Scutari Lake, practically all the rivers drain north, ultimately into the Danube. The high mountains have a large number of peaks over 2,000 m. in height, culminating in Mt. Durmitor in the north-west. The coastal area is mainly composed of Tertiary substrata, while the inland mountainous districts are largely Mesozoic, especially Cretaceous and Triassic, in age. Limestones predominate, and much of the district is now karst. The climate shows a very wide range, from Mediterranean conditions on the coast to Central European and even Alpine conditions inland. This largely accounts for the richness of the flora in species, since Central European and Mediterranean types can flourish in different parts.

Two thousand three hundred and sixty-two species of Phanerogams are known from the district, including 210 Balkan Peninsular endemics, of which 20 are only known from Montenegro. The predominant families are: *Gramineae* (165), *Cyperaceae* (69), *Liliaceae* (65), *Orchidaceae* (44), *Caryophyllaceae* (121), *Ranunculaceae* (77), *Cruciferae* (120), *Rosaceae* (96), *Leguminosae* (201), *Umbelliferae* (125), *Borraginaceae* (46), *Labiatae* (109), *Scrophulariaceae* (115), *Rubiaceae* (44), *Dipsacaceae* (30), *Campanulaceae* (39), and *Compositae* (301). Twenty-one families of the Balkan Peninsular flora are not represented in Montenegro, and no family is entirely limited to this district.

The vegetation shows a great range of plant communities. Mediterranean macchie occur in the coastal districts. Pseudomacchie and especially shiblyak are found inland in the lower hill and montane zones. The forests are considerably depauperated, but zones of oak, beech, and conifers should naturally cover most of the country below the tree altitudinal limit, and in places still do so. In the lowlands the marsh flora and vegetation are excellently developed. The greater part of the district is now covered with rock and karst communities, with a rich flora containing many endemic species, but a very open low vegetation. Phytogeographically Montenegro is the southernmost of our districts which is predominantly Illyrian. Its narrow lowland coastal strip is to be associated with Dalmatia and coastal Albania, while the bulk of the country must be joined with Bosnia, eastern Hercegovina, and northern Albania. The floristic exploration of Montenegro is fairly well advanced, at least relatively to that of much of Albania and the Sandjak of Novi Pazar.

It is of interest here to refer to several essentially Bulgarian species which reach to the western parts of the Balkan Peninsula. *Pinus peuce* Griseb. is now known from Albania, North Macedonia, North Bulgaria, the Rodopes, Serbia, and Montenegro; *Geum bulgaricum* Vis. et Panč. occurs in Albania, the Rodopes, Serbia, Montenegro, and Hercegovina; *Knautia magnifica* Boiss. et Orph. is recorded from Greece, Albania, South Macedonia, North Bulgaria, the Rodopes, Serbia, Montenegro, Bosnia, Hercegovina, and South Croatia; *Jasione orbiculata* Griseb. [sensu Stoyanoff in *Notizbl. Bot. Gart. u. Mus. Berlin-Dahlem*, ix. 545 (1926)] is found in Epirus, Albania, North Macedonia, North Bulgaria, the Rodopes, Serbia, Montenegro, Bosnia, and Hercegovina; finally *Aquilegia aurea* Janka is known from North Macedonia, North Bulgaria, and the Rodopes. The Bulgarian element in the western districts of the Balkan Peninsula is certainly slight but is just sufficient to indicate a subsidiary connexion, which is further emphasized, although by no means fully elucidated at present, by our studies on the Alpine high mountain flora of the Balkan Peninsula. We were informed by a head

forest officer in charge of the Rodope area in July 1926 that *Picea omorika* Willk. grows in the western Rodopes. He accurately described the tree, and if his information is correct there will be a most important addition to the meagre list above.

12. **Bosnia.** This large and entirely inland district is for the greater part hilly and mountainous, with only small plains, valleys, and poljes. The chains and groups of mountains are rather irregularly arranged, but many of them show a general north-west to south-east orientation. This is the general direction of the Dinaric Alps on the west, and even in the interior such an orientation can frequently be detected. The drainage is almost entirely in a general northward direction into the Save and thence to the Danube and Black Sea, although the Adriatic is so much nearer. This is entirely due to the importance as a watershed of the Dinaric Alps, which in their Bosnian portion are not breached by any river. Where karst conditions are common underground drainage is frequent. The rocks are largely of Mesozoic age with limestones predominant. In the north-east there are extensive beds of Neogene freshwater deposits. The climate is distinctly Central European. The rainfall is abundant and the winter fairly severe.

Two thousand and twenty-two species of Phanerogams are known from the district, including 169 Balkan Peninsular endemics, of which 22 are recorded only from Bosnia. The dominant families in the flora are: *Gramineae* (139), *Cyperaceae* (58), *Liliaceae* (57), *Orchidaceae* (52), *Caryophyllaceae* (122), *Ranunculaceae* (64), *Cruciferae* (102), *Rosaceae* (104), *Leguminosae* (155), *Umbelliferae* (97), *Borraginaceae* (38), *Labiatae* (79), *Scrophulariaceae* (100), *Rubiaceae* (30), *Campanulaceae* (38), and *Compositae* (252). Twenty-five families of the Balkan Peninsular flora are not known to be represented in Bosnia, and no family is limited to this district. Macchie and other characteristic associations of the Mediterranean domain are entirely absent. Forests in a primitive condition still occur in the western mountains, but large areas of the more accessible parts have been denuded of tree growth with the consequence that karst conditions have been initiated or at least intensified. Shiblyak is abundant and rock and stony ground communities are most characteristic. Botanically the district is Central European–Illyrian. That is to say, while the climatic conditions allow only Central European types of vegetation, a large proportion of the species are endemic to the north-west of the Balkan Peninsula or at least have their centre of distribution, and probably their place of origin, in the Illyrian lands. Floristically Bosnia has been well explored and the rich collections, largely in Vienna and Sarajevo, would suffice for the publication of a fairly complete flora.

13. **Hercegovina.** This is a smaller district than the last and though

it is not separated by any well-defined natural boundary has a number of very distinctive general features. Two narrow strips reach the coast. The district is hilly and mountainous with limestones predominating. The hills and mountains belong entirely to the Dinaric system in the broad sense, that is, to the folded mountains of the north-west of the Balkan Peninsula, with a general north-west to south-east orientation. The main drainage is into the Adriatic by the river Narenta and its tributaries. This is an important contrast with Bosnia. The climate in the lowlands and valleys is essentially Mediterranean, though remarkable for its extremes and the great heat of summer. The mountainous parts have a more transitional type of climate. The bora is frequent and severe in the winter.

One thousand nine hundred and forty species of Phanerogams are known from the district, including 170 endemics, of which 11 are recorded only from Hercegovina. The dominant families are: *Gramineae* (138), *Cyperaceae* (45), *Liliaceae* (72), *Orchidaceae* (40), *Caryophyllaceae* (109), *Ranunculaceae* (56), *Cruciferae* (83), *Rosaceae* (87), *Leguminosae* (165), *Euphorbiaceae* (30), *Umbelliferae* (102), *Borraginaceae* (36), *Labiatae* (89), *Scrophulariaceae* (89), and *Compositae* (231). Twenty-four families of the Balkan Peninsular flora are not recorded from this district and no family is entirely restricted to it. Both the flora and, in the lowlands, the vegetation are more Mediterranean in character than in the neighbouring district of Bosnia. The forests have been very largely destroyed, but some macchie, pseudomacchie, and shiblyak occur. The karst communities and those of rocky and stony places generally are most characteristic. Except in association with the Narenta the aquatic and marsh vegetation and flora are poor. The essentially Mediterranean character of much of the flora of the lower zones in Hercegovina, in contrast with that of Bosnia, is clearly shown by the fact that 204 species of essentially Mediterranean plants (excluding those endemic to the district) are known from Hercegovina but not from Bosnia. These include such well-known species as: *Juniperus macrocarpus* S. et S., *J. phoenicea* L., *Pinus halepensis* Mill., *Gastridium ventricosum* Schinz et Thell., *Asphodeline liburnica* Reichb., *A. lutea* Reichb., *Asphodelus fistulosus* L., *A. microcarpus* Viv., *Sternbergia lutea* Ker-Gawl, *Hermodactylus tuberosus* Salisb., *Romulea bulbocodium* Seb. et Maur., *Orchis quadripunctata* Cyr., *Serapias lingua* L., *Quercus ilex* L., *Delphinium peregrinum* L., *Laurus nobilis* L., *Aethionema graecum* Boiss. et Heldr., *Erysimum pusillum* Bory et Chaub., *Reseda alba* L., *Calycotome infesta* Guss., *Coronilla cretica* L., *Hippocrepis ciliata* Willd., *Hymenocarpus circinnatus* Savi, *Onobrychis caput-galli* Lam., *Trifolium cherleri* L., *Rhus coriaria* L., *Cistus salviifolius* L., *Myrtus communis* L., *Bifora testicu-*

lata DC., *Tordylium apulum* L., *Phillyrea latifolia* L., *Vitex agnus-castus* L., *Satureia cuneifolia* Ten., *Antirrhinum majus* L., *Acanthus spinosissimus* Pers., *Vaillantia muralis* L., *Lonicera etrusca* Santi, *Campanula erinus* L., *Inula verbascifolia* Hausskn., *Pallenis spinosa* L., *Picnomon acarna* Cass., *Reichardia picroides* Roth, *Rhagadiolus stellatus* Willd., and *Zacyntha verrucosa* Gaertn. Hercegovina has been relatively well explored floristically and there is no doubt that the southern parts and the main Narenta basin must be relegated with Dalmatia to the Mediterranean domain.

14. **Dalmatia.** This long coastal and island district is entirely within the sphere of influence of the Adriatic Sea. The main chain of the Dinaric Alps in the east is included here in Bosnia, thus making Dalmatia a fairly homogeneous district in spite of its considerable latitudinal extent. The hills and mountains, the valleys and poljes, the coast, and many of the island groups have a general north-west to south-east trend, approximately parallel with the Dinaric Alps. The rivers are mostly short, and, though the larger ones have irregular courses, the drainage is entirely into the Adriatic. The geological formations are mainly of Tertiary, Cretaceous, and Triassic ages, with limestones predominating. A considerable proportion of the limestone area is now more or less in a karst condition. The coastal parts, especially in the south, have a typical Mediterranean climate, which is modified inland so as to approach Central European conditions. Areas open to the north-east are subject to the bora which modifies the vegetation, and especially prevents the appearance of typical macchie. The rainfall is, for most stations, high, but the karsted nature of so much of the country almost nullifies any benefits to the vegetation from this factor. The known Phanerogamic flora consists of 2,292 species, including 160 Balkan Peninsular endemics, of which 25 are limited to Dalmatia. The dominant families are: *Gramineae* (176), *Cyperaceae* (50), *Liliaceae* (77), *Orchidaceae* (51), *Caryophyllaceae* (99), *Ranunculaceae* (69), *Cruciferae* (125), *Rosaceae* (51), *Leguminosae* (244), *Euphorbiaceae* (34), *Umbelliferae* (128), *Borraginaceae* (45), *Labiatae* (116), *Scrophulariaceae* (79), *Rubiaceae* (30), *Campanulaceae* (38), and *Compositae* (287). Fourteen families of the Balkan Peninsular flora are not known from the district and no family is entirely limited to it. Macchie are well developed along the coast and in the south attain a luxuriance greater than elsewhere in the Balkan Peninsula, and woods of *Pinus halepensis* Mill. also occur. In northern Dalmatia and in some of the inland parts shiblyak and transitions between this and macchia are frequent. Beech and conifers occur at higher altitudes, but most of the forests have been entirely or partially destroyed. The communities of stony and rocky ground cover a very large area and

are the most characteristic vegetational features of Dalmatia. The district certainly belongs to the Mediterranean domain, although the percentage of species of limited distribution in the flora is fairly high.

An interesting phytogeographical fact is that a considerable number of species from Crete, Greece, or Corfu, occur also in Dalmatia but are not known from an intermediate Balkan Peninsular district. Examples of this type of distribution are afforded by the following species: *Triglochin bulbosa* L. (1, 2, 4a, 14), *Avellinia michelii* Parl. (1, 2, 2a, 14), *Melica minuta* L. (1, 2, 2a, 4a, 6b, 14), *Scleropoa hemipoa* Delile (2, 14), *Sporobolus arenarius* Duval-Jouve (1, 2, 2a, 6a, 7, 9, 14), *Carex illegitima* Cesati (1, 2, 14), *Allium neapolitanum* Cyr. (1, 2, 2a, 3b, 14, 16), *Hyacinthus dubius* Guss. (1, 2, 4a, 14), *Muscari parviflorum* Desf. (2, 14), *Aceras longibracteata* Reichb. (1, 2, 2a, 14), *Ophrys tenthredinifera* Willd. (1, 2, 2a, 7, 14), *Cytinus hypocistis* L. (1, 2, 2a, 4a, 7, 14, 16), *Fumaria gaillardotii* Boiss. (2, 14, 16), *F. macrocarpa* Parl. (1, 2, 2a, 6a, 14), *Papaver setigerum* DC. (2, 2a, 14), *Crambe hispanica* L. (2, 3, 4a, 14), *Sedum stellatum* L. (1, 2, 4a, 14), *Saxifraga hederacea* L. (1, 2, 6a, 6b, 14), *Ceratonia siliqua* L. (1, 2, 2a, 14, 16), *Hedysarum capitatum* Desf. (2, 14), *Hippocrepis multisiliquosa* L. (2, 14, 15), *Medicago praecox* DC. (2, 2a, 6b, 14), *M. scutellata* All. (1, 2, 7, 14, 15, 16), *Melilotus messanensis* L. (2, 2a, 4a, 7, 14), *Ononis mitissima* L. (1, 2, 7, 14), *O. ornithopodioides* L. (2, 2a, 14), *O. ramosissima* Desf. (1, 2a, 14), *Erodium chium* Willd. (2, 2a, 7, 14), *Callitriche truncata* Guss. (2, 14), *Malope malacoides* L. (1, 2, 4a, 7, 14), *Thymelaea hirsuta* Endl. (1, 2, 2a, 7, 14), *Bupleurum semicompositum* L. (1, 2, 2a, 14, 15), *Daucus gingidium* L. (1, 2a, 14), *Ridolfia segetum* Moris. (2, 2a, 4a, 7, 14, 15), *Limonium cancellatum* Maire et Petitmengin (2, 14, 15, 16), *L. cosyrense* O. Kuntze (2, 2a, 14), *Styrax officinalis* L. (1, 2, 2a, 7, 14), *Cuscuta globularis* Bert. (1, 2, 2a, 14), *Lavandula spica* L. (2, 2a, 14), *Majorana onites* Benth. (1, 2, 2a, 14), *Micromeria microphylla* Benth. (1, 14), *Linaria micrantha* Spreng. (1, 2, 2a, 14), *L. triphylla* Mill. (1, 2, 2a, 14, 15), *Orobanche lavandulacea* Reichb. (1, 2, 4a, 14), *Plantago cynops* L. (1, 4a, 14), *P. serraria* L. (2, 4a, 14), *Galium saccharatum* All. (2, 2a, 4a, 14), *Kentranthus calcitrapa* L. (1, 2, 2a, 6a, 14), *Cichorium pumilum* Jacq. (1, 2, 2a, 7, 14), and *Cirsium stellatum* All. (2, 4a, 14). It is certain that some of the species showing this kind of discontinuity in their known distribution will be found to occur in intermediate districts, more particularly in Epirus and Albania. The number of species involved, however, is sufficiently great to make it improbable that the discontinuity is merely apparent. While the original dispersal of the species involved may have led immediately to their present discontinuous distribution, it is possible that a continuous dispersal actually occurred over land now sunk beneath the

Adriatic. It is unfortunate that the geological history of the Adriatic involves important unsettled problems, and until geologists have sufficient facts available for reaching reliable conclusions phytogeographers can do little more than state the facts of distribution.

15. **South Croatia.** This district is geographically and geologically a northern continuation of North Dalmatia. It is of particular interest as linking the mountains of the north-west of the Balkan Peninsula with the south-eastern extensions of the Alps. The Kapela, Plješevica, and Velebit ranges have the same general north-west to south-east orientation as the Dalmatian mountains, and karst conditions are very prevalent. The rivers are of small size and a great many of them disappear underground before reaching the sea. A narrow coastal strip has essentially a modified Mediterranean type of climate. The inland districts are decidedly Central European with heavy winter snowfalls in some parts and the frequent occurrence of the bora. The rainfall is heavy over much of the country, but especially in the coastal mountains.

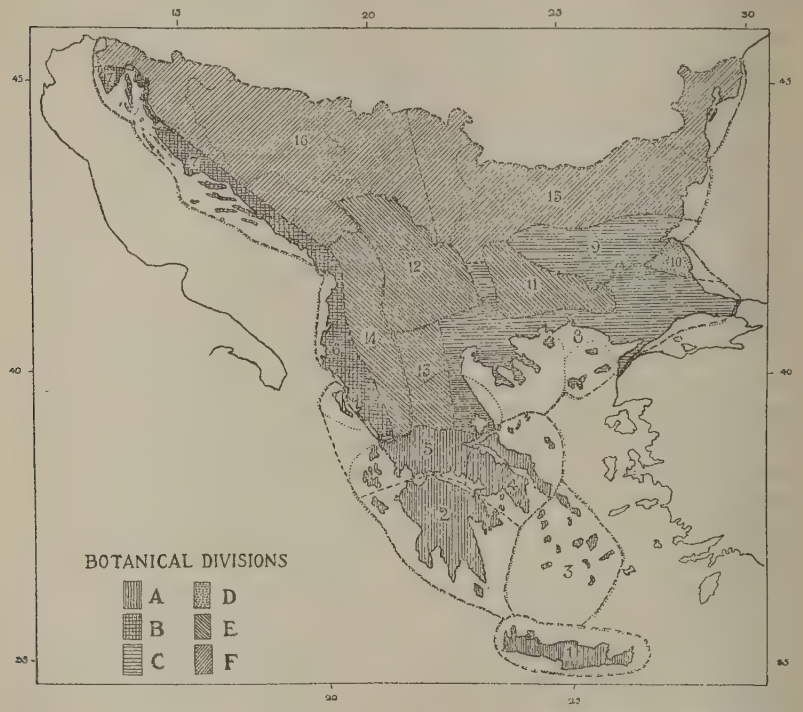
Two thousand one hundred and sixty species of Phanerogams are known from the district, including 80 Balkan Peninsular endemics, of which 7 are recorded only from South Croatia. The dominant families are: *Gramineae* (169), *Cyperaceae* (67), *Liliaceae* (68), *Orchidaceae* (39), *Caryophyllaceae* (100), *Ranunculaceae* (77), *Cruciferae* (108), *Rosaceae* (85), *Leguminosae* (167), *Umbelliferae* (123), *Borraginaceae* (34), *Labiatae* (91), *Scrophulariaceae* (93), *Campanulaceae* (35), and *Compositae* (260). Twenty families of the Balkan Peninsular flora as a whole are absent from the district, and no family is entirely limited to it.

The forests have been very largely destroyed, but the remains indicate a normal altitudinal sequence of a very depauperated and discontinuous coastal belt of evergreen shrubs and trees, scarcely to be termed macchie, oaks, mixed forest, beech, and conifers. Brushwood of shiblyak nature is common, but communities of stony and rocky habitats are the most prevalent, especially those associated with karst limestone. South Croatia is botanically a transitional region with the Illyrian flora dominant.

16. **Istria.** This, the most north-western district of the Balkan Peninsula, consists of the Istrian Peninsula proper and a slight extension in the north to include the bulk of what is generally known as the Karst. It is a broken area dominated by limestone plateaus and hills which culminate in Mt. Maggiore. The superficial drainage is very inconspicuous since most of the rivers and streams run underground for at least a part of their courses. The rocks are almost entirely Tertiary and Cretaceous limestones and Tertiary arenaceous deposits (flysch). In the south the climate approaches a Mediterranean type, though the rainfall is relatively higher and more equally distributed

throughout the year than in completely Mediterranean districts. Here, too, protection is obtained from the bora. On the higher Karst the winter conditions are often very severe and the bora is frequent and strong.

The Phanerogamic flora consists of 1,970 known species, including 48 Balkan Peninsular endemics, of which 7 are limited to the district. The dominant families are: *Gramineae* (162), *Cyperaceae* (58), *Liliac-*



eae (69), *Orchidaceae* (55), *Caryophyllaceae* (71), *Ranunculaceae* (64), *Cruciferae* (86), *Rosaceae* (80), *Leguminosae* (184), *Euphorbiaceae* (31), *Umbelliferae* (97), *Borraginaceae* (34), *Labiatae* (86), *Scrophulariaceae* (82), *Rubiaceae* (31), and *Compositae* (230). Nineteen families of the Balkan Peninsular flora are not represented in Istria, and no family is entirely restricted to this district. The vegetation, for so small a district, includes a wide range of plant communities. In the south and on the west to about half-way up the Istrian Peninsula Mediterranean macchie occur, correlated with the climate and the absence of the bora. On the hills and plateaus remains of oak and mixed deciduous woods occur in a few places, but have been destroyed over most of the

area. Mt. Maggiore rises into the beech region. On its lower eastern slopes are woods and brushwoods of *Laurus nobilis*. The dominant communities are those of rocky and stony limestone habitats, such as karst-brushwood of deciduous shrubs and junipers, and open vegetation amongst limestone boulders and pavements. A considerable number of species are limited either to the calcareous or to the arenaceous substrata.

BOTANICAL SUBDIVISIONS.

Attempts to divide a given area into 'natural' divisions are seldom completely satisfactory. This is particularly true when the plant life is the basis of division. On the other hand, such attempts may be valuable by indicating in a clear manner general phytogeographical relationships and the position of barriers and lines of extension, and also in indicating subjects for future research. The mistake is to attempt greater completeness than is warranted by the available data. The detailed investigations on which the present work is based have indicated very clearly that every species has a distribution not exactly like and, with few exceptions, apparently quite independent of, that of any other species. Each has had in details a unique history, special barriers, and its own rate of spread. It follows that in attempting to deal with the masses of species forming a flora or vegetation only generalizations can be made to which there are exceptions for individual species. The botanical subdivisions suggested below are tentative only. They will need much modification when botanical investigation of the Balkan Peninsula is more advanced, and, especially, they will need to be further subdivided into smaller units.

The following scheme is proposed as a result of ten years' studies:

A. Southern.
   1. Crete.
   2. Peloponnese with Cephalonia.
   3. The Cyclades.
   4. Attica, Boeotia, Euboea, and the Magnesian Islands.
   5. Northern Greece and the Ionian islands (except Cephalonia).

B. Western coastal.
   6. Western Epirus and western Albania.
   7. Dalmatia, for the greater part, and coastal strips of Montenegro, Hercegovina, and southern Istria.

C. East-central.
   8. Thessaly, South Macedonia (excluding the Pindus), the middle Struma valley, Thrace, and the Thracian islands.
   9. South Bulgaria.

D. Eastern.

10. The Strandja area.

E. Central.

11. The Rodope massif.
12. North Macedonia and the greater part of the Sandjak of Novi Pazar.
13. The Pindus and immediately associated chains.
14. Eastern Epirus and eastern Albania.

F. Northern.

15. The Dobruja, North Bulgaria (excluding the middle Struma valley), and eastern Serbia. This is essentially the Danubian subdivision.
16. Western Serbia, Bosnia, South Croatia, and much of Montenegro and Istria, with parts of northern Albania, Hercegovina, and Dalmatia. This is essentially the Illyrian subdivision excluding the truly Mediterranean parts.

Of the main groups A and B fall entirely within the Mediterranean domain, C is transitional with a strong Mediterranean bias, D is Pontic with floristic affinities with northern Asia Minor and the Caucasus, E is transitional with a strong Central European bias, and F is essentially Central European with local Mediterranean enclaves.

XV

FLORISTIC AND VEGETATIONAL DISTRIBUTION OF BALKAN PENINSULAR SPECIES OUTSIDE THE PENINSULA

General. Classifying the distributions of species and attempting thereby to discover generalizations regarding the history of a taxonomic group, the development of a flora, or, of still wider import, methods of evolution of taxonomic groups, is a fundamental function of phytogeography. It is necessary not only to consider the distribution within a defined area but also the general distribution of all the species known for a given flora before answers to the numerous questions which arise in the course of phytogeographical studies can be attempted. Moreover, the phytogeographer is frequently led into considering all the species of a genus or family and even into monographic work, unless this has been satisfactorily done in recent times. The position of the Balkan Peninsula as the most eastern of the three great peninsulas of southern Europe, the orientation of its mountain systems, and its known geological history make a study of its general floristic relationships a matter of exceptional phytogeographical importance. Fortunately Kew is very rich in European and Oriental plants and the collections in the Herbarium, supplemented by the large Library, are sufficient to give a sound basis to research on the general distribution of species which occur in the Balkan Peninsula. That there are yet many gaps in our knowledge needs no emphasis, but merely to wait for perfection of data before using them can lead to no scientific advance.

In this chapter an attempt is made to evaluate the botanical connexions between the Balkan Peninsula and other areas, large and small, immediately contiguous or separated by stretches of sea. For this purpose a range of symbols, in the form of Roman numerals, has been used in the detailed unpublished work on the taxonomy and distribution of the individual species. These symbols are employed to a more limited extent in this work. The distributions represented by the symbols were known, as a result of fairly wide personal experience, to be those most commonly represented in the Balkan Peninsular flora and gradually the scheme was made sufficiently detailed for the end in view. The categories containing the most widely distributed species are considered first and, in general, the categories of less and less widely distributed species follow successively.

The figures obtained are as accurate as it has been possible to make them at present. That they will have to be somewhat modified when the results of further botanical exploration both in the Balkan Peninsula and in neighbouring countries, especially Asia Minor, become available, is certain. On the other hand it is doubtful if the necessary alterations will modify very much the relative values of the figures or will invalidate the cautious conclusions I have drawn from them. The figures given should only be used in conjunction with the text and not for purposes other than those for which they have been compiled.

Explanation of Symbols. The respective columns include species with the following distributions: I. Cosmopolitan (in the sense of occurring north and south of the equator and in both the Old and New Worlds). I.a Old World. II. North Temperate. III. East North Temperate. IV. General European. V. Mediterranean Regional. VI. Mediterranean Basin. VII. West Mediterranean Basin. VIII. South European. IX. Italian. X. East Mediterranean. XI. Oriental. XII. Central European. XIII. Dacian. XIV. Pannonian. XIV.a Pontic. XV. Alpine. XVI. West North African. XVII. Egyptian. XVIII. Caucasian. XIX. Balkan Peninsular. XX. Endemic.

BALKAN PENINSULAR SPECIES WHICH HAVE A WIDE GENERAL DISTRIBUTION (I—III).

Each species can only be listed under one of the categories and a total of 1,114 species have distributions ranging from cosmopolitan to East North Temperate. This represents 17 per cent. of the total flora.

A glance over the figures for the individual families yields some interesting conclusions as follows:

1. The families with many species occurring as weeds of cultivation and ruderals have either a high percentage of 'wides' or at least contribute absolute high figures. Examples are: *Gramineae*, *Polygonaceae*, *Chenopodiaceae*, *Amarantaceae*, *Portulacaceae*, *Caryophyllaceae*, *Ranunculaceae*, *Cruciferae*, *Rosaceae*, *Leguminosae*, *Oenotheraceae*, *Umbelliferae*, *Borraginaceae*, *Labiatae*, *Scrophulariaceae*, and *Compositae*.

2. The families whose Balkan Peninsular species are all, or for the greater part, aquatic, marsh, or bog plants have also a high percentage of 'wides'. Examples are: *Typhaceae*, *Potamogetonaceae*, *Naiadaceae*, *Hydrocharitaceae*, *Cyperaceae*, *Lemnaceae*, *Juncaceae*, and *Droseraceae*.

3. The entirely woody families *Salicaceae* and *Betulaceae* have a good proportion of 'wides', while the *Taxaceae*, *Juglandaceae*, *Fagaceae*, *Cornaceae*, *Ebenaceae*, *Styracaceae*, and *Oleaceae* have none.

4. The *Cruciferae*, *Leguminosae*, *Umbelliferae*, and *Compositae* contribute fewer species to the total 'wides' than would be expected from

	I. *Cosmopol.*	I.a *Old World*	II. *N. Tempt.*	III. *E. N. Tempt.*	IV. *Gener. Eur.*	V. *Medit. Reg.*	VI. *Medit. Bas.*	VII. *W. Medit. Bas.*	VIII. *S. Eur.*	IX. *Italian*	X. *E. Medit. Bas.*	XI. *Oriental*	XII. *Cent. Eur.*	XIII. *Dacian*	XIV. *Pannonian*	XIV.a *Pontic*	XV. *Alpine*	XVI. *W. N. African*	XVII. *Egyptian*	XVIII. *Caucasian*	XIX. *Balk. Penins.*	XX. *Endemics*
Taxaceae	..	..	..	..	1	..	..	..	..	..	..	1	..	..	..	..	..	..	..	1	..	..
Pinaceae	..	..	2	..	..	1	4	1	1	1	3	1	5	..	..	..	1	..	..	10	..	3
Gnetaceae	..	..	..	1	..	1	..	..	..	..	1	..	..	..	..	..	..	..	..	1	..	..
Typhaceae	1	..	1	3	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..
Sparganiaceae	..	..	2	1	1	1	..	..	..	..	..	..	1	..	..	..	..	..	..	1	..	..
Potamogetonaceae	14	..	6	1	2	1	3	..	..	..	..	..	1	..	..	..	..	..	..	1	..	..
Naiadaceae	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Scheuchzeriaceae	2	..	..	..	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Alismataceae	1	1	..	1	..	..	2	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..
Butomaceae	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Hydrocharitaceae	1	..	..	1	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..
Gramineae	25	4	34	45	12	66	32	10	15	6	12	9	36	11	10	11	22	3	2	78	19	33
Cyperaceae	13	12	24	37	7	16	5	3	2	1	2	1	27	1	3	5	17	..	..	18	..	2
Araceae	..	..	2	..	1	2	2	..	..	..	1	..	..	..	..	1	..	..	..	3	..	4
Lemnaceae	4	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Juncaceae	6	1	7	7	1	5	4	..	2	1	1	1	7	1	1	1	9	..	..	4	1	..
Liliaceae	..	..	2	29	6	20	33	..	11	5	6	19	16	6	7	13	9	..	..	47	7	93
Amaryllidaceae	..	..	..	..	..	2	5	1	5	..	..	2	4	..	..	2	1	..	..	4	1	3
Dioscoreaceae	..	..	..	..	..	1	..	..	..	..	..	..	1	..	..	..	..	..	..	1	..	1
Iridaceae	..	..	..	1	..	8	10	..	4	2	..	5	7	1	6	3	1	..	..	10	11	15
Orchidaceae	..	..	3	16	3	10	26	2	3	..	1	7	23	..	..	..	3	..	..	22	3	13
Salicaceae	..	..	4	16	1	..	..	..	2	..	..	..	3	..	..	..	9	..	..	1	1	..

THE GENERAL DISTRIBUTION OF THE SPECIES OF EACH FAMILY IN THE BALKAN PENINSULAR FLORA (*cont.*)

	I. *Cosmopol.*	I.a *Old World*	II. *N. Tempt.*	III. *E. N. Tempt.*	IV. *Gener. Eur.*	V. *Medit. Reg.*	VI. *Medit. Bas.*	VII. *W. Medit. Bas.*	VIII. *S. Eur.*	IX. *Italian*	X. *E. Medit. Bas.*	XI. *Oriental*	XII. *Cent. Eur.*	XIII. *Dacian*	XIV. *Pannonian*	XIV.a *Pontic*	XV. *Alpine*	XVI. *W. N. African*	XVII. *Egyptian*	XVIII. *Caucasian*	XIX. *Balk. Penins.*	XX. *Endemics*
Juglandaceae	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	1	..	..
Betulaceae	..	..	2	5	1	..	..	..	..	..	..	2	1	..	..	..	..	..	..	3	1	..
Fagaceae	..	..	..	..	2	1	4	..	3	2	1	2	2	..	2	3	..	..	..	5	4	..
Ulmaceae	..	..	..	2	..	1	..	..	..	..	1	2	2	1	..	..	..	..	..	3	..	..
Moraceae	..	..	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..
Urticaceae	1	..	..	1	..	2	3	..	..	1	..	..	2	..	..	..	..	..	..	3	1	..
Loranthaceae	..	..	..	1	..	1	..	..	1	..	..	..	1	..	..	..	..	..	..	1	..	..
Santalaceae	..	..	..	4	..	1	2	..	..	1	1	1	3	1	3	..	..	..	..	1	2	3
Aristolochiaceae	..	..	..	1	1	..	1	..	..	..	..	1	..	..	..	..	..	..	..	1	..	5
Rafflesiaceae	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Polygonaceae	11	2	6	11	1	3	4	..	2	1	1	1	4	..	1	..	3	..	..	4	2	3
Chenopodiaceae	9	1	10	32	1	..	4	..	..	..	..	..	1	2	1	2	..	..	..	4	..	1
Amarantaceae	3	1	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cynocrambaceae	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Phytolaccaceae	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Aizoaceae	..	2	..	..	..	3	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..
Portulacaceae	1	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Caryophyllaceae	9	5	7	37	13	15	41	1	20	5	10	28	25	15	18	10	14	..	..	44	33	175
Nymphaeaceae	..	..	..	3	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..
Ceratophyllaceae	1	..	..	..	1	..	..	..	..	..	..	..	1	..	..	..	..	..	..	1	..	..
Ranunculaceae	..	..	4	39	6	13	21	..	7	..	5	19	40	2	8	7	12	..	..	36	10	37
Berberidaceae	..	..	..	1	1	..	..	..	..	..	1	2	1	..	..	1	..	..	..	2	1	..

Lauraceae	.	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..
Papaveraceae	.	..	..	1	6	..	10	7	..	..	1	1	5	10	1	..	1	1	..	1	11	3	10
Cruciferae	.	4	..	6	25	15	26	38	..	22	9	6	34	62	8	11	4	12	..	1	63	28	94
Capparidaceae	.	..	..	..	..	..	1	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Resedaceae	.	..	..	..	..	..	2	1	..	1	..	1	..	3	1	1	1	..	..	..	2	..	1
Droseraceae	.	..	1	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Crassulaceae	.	..	..	..	2	5	1	12	..	2	..	6	3	12	1	3	..	3	..	..	6	3	16
Saxifragaceae	.	..	..	8	2	2	..	2	..	..	2	1	..	12	..	2	..	15	..	..	6	4	9
Platanaceae	.	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..
Rosaceae	.	1	..	11	32	12	14	22	..	10	2	4	12	56	5	3	8	14	..	..	51	8	24
Leguminosae	.	..	..	..	46	20	58	119	6	43	8	67	16	43	26	18	9	9	..	..	125	29	106
Geraniaceae	.	2	..	..	10	2	5	7	..	2	2	2	1	6	1	1	3	1	..	..	11	1	5
Oxalidaceae	.	..	..	..	1	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Linaceae	.	..	..	..	1	1	6	4	..	2	1	1	..	3	2	1	1	1	..	..	13	4	14
Zygophyllaceae	.	..	1	..	2	..	..	1	..	..	..	1	..	..	..	..	..	..	1	1	..	..	..
Rutaceae	.	..	..	..	1	..	..	2	..	1	..	1	..	..	1	..	..	..	..	..	..	2	6
Polygalaceae	.	..	..	..	1	1	..	2	..	1	..	1	3	5	..	..	..	1	..	..	4	2	4
Euphorbiaceae	.	..	..	..	6	2	5	15	1	5	1	5	5	15	4	4	3	..	..	..	19	5	20
Callitrichaceae	.	..	1	..	1	1	..	1	..	2	..	..	..	3	..	..	..	..	..	..	1	..	..
Buxaceae	.	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Empetraceae	.	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..
Coriariaceae	.	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Anacardiaceae	.	..	..	..	..	..	..	4	..	..	..	..	1	1	..	..	..	..	..	..	3	..	..
Aquifoliaceae	.	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..
Celastraceae	.	..	..	..	2	..	..	..	..	..	..	..	1	2	..	..	..	..	..	..	1	..	1
Staphyleaceae	.	..	..	..	..	..	..	..	..	..	..	..	1	1	..	..	..	..	..	..	1	..	..
Aceraceae	.	..	..	..	..	..	2	2	..	1	2	..	1	3	..	..	..	..	..	..	4	1	2
Hippocastanaceae	.	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..
Balsaminaceae	.	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Rhamnaceae	.	..	..	..	2	..	2	1	..	1	..	1	1	2	..	1	1	1	..	..	2	2	7
Vitaceae	.	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..
Tiliaceae	.	..	..	..	..	1	..	..	..	1	..	..	..	2	..	..	..	..	..	..	1	1	..
Malvaceae	.	..	..	..	5	1	4	6	..	3	1	3	2	4	..	1	1	..	..	..	9	3	2

THE GENERAL DISTRIBUTION OF THE SPECIES OF EACH FAMILY IN THE BALKAN PENINSULAR FLORA (*cont.*)

	I. *Cosmopol.*	I.a *Old World*	II. *N. Tempt.*	III. *E. N. Tempt.*	IV. *Gener. Eur.*	V. *Medit. Reg.*	VI. *Medit. Bas.*	VII. *W. Medit. Bas.*	VIII. *S. Eur.*	IX. *Italian*	X. *E. Medit. Bas.*	XI. *Oriental*	XII. *Cent. Eur.*	XIII. *Dacian*	XIV. *Pannonian*	XIV.a *Pontic*	XV. *Alpine*	XVI. *W. N. African*	XVII. *Egyptian*	XVIII. *Caucasian*	XIX. *Balk. Penins.*	XX. *Endemics*
Hypericaceae	..	..	..	5	4	1	2	..	..	..	8	2	2	2	4	3	..	..	..	7	3	23
Elatinaceae	..	..	..	..	..	..	2	..	..	..	..	..	4	..	..	..	..	..	..	..	..	..
Frankeniaceae	..	..	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..
Tamaricaceae	..	..	..	..	..	..	..	2	..	..	1	4	..	..	..	..	..	..	..	..	1	..
Cistaceae	..	..	..	..	1	7	9	1	2	..	5	..	5	..	..	1	2	..	..	8	1	2
Violaceae	..	..	..	7	3	1	2	..	2	..	3	2	7	..	1	2	2	..	..	6	1	33
Datiscaceae	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	1	..	..
Thymelaeaceae	..	..	..	2	..	2	2	..	1	..	2	2	3	..	..	1	..	..	..	3	1	1
Elaeagnaceae	..	..	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Lythraceae	2	..	..	5	1	..	2	..	..	..	..	1	..	..	..	..	..	..	..	2	..	..
Punicaceae	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..
Myrtaceae	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Oenotheraceae	1	1	..	10	..	1	2	..	1	..	..	..	7	..	..	3	2	..	..	4	..	..
Hippuridaceae	1	..	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cynomoriaceae	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Araliaceae	..	..	..	1	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..
Umbelliferae	2	1	1	23	15	23	29	1	26	10	20	14	55	13	18	13	11	..	..	61	7	107
Cornaceae	..	..	..	..	1	..	1	..	..	..	..	..	1	..	1	1	..	..	..	1	..	..
Pirolaceae	..	..	5	1	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	1	..	..
Ericaceae	..	..	7	..	..	..	2	1	..	..	2	..	3	1	1	1	8	..	..	4	1	..
Primulaceae	5	..	..	6	3	1	1	1	2	..	4	1	10	..	1	2	6	1	..	10	..	12
Plumbaginaceae	..	..	..	1	2	..	6	1	3	1	7	..	2	2	..	1	1	..	..	3	1	13

Ebenaceae	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..
Styracaceae	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Oleaceae	..	..	..	..	2	3	3	2	..	..	..	2	..	..	1	3	..	..	..	6	1	2	
Gentianaceae	..	..	3	4	4	1	4	..	3	..	2	..	10	..	2	4	9	..	..	..	5	4	
Apocynaceae	..	..	..	1	..	1	1	..	..	..	2	..	1	1	1	..	..	..	..	3	..	1	
Asclepiadaceae	..	..	..	1	..	..	1	..	1	..	2	3	1	..	..	1	..	..	..	3	1	5	
Convolvulaceae	3	..	..	6	..	3	5	2	2	..	2	4	2	..	1	3	..	..	..	14	..	3	
Polemoniaceae	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Borraginaceae	..	..	2	19	2	18	7	..	5	3	21	4	16	8	7	9	3	..	..	23	9	47	
Verbenaceae	2	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..	..	..	2	..	1	
Labiatae	2	..	..	36	14	14	23	2	21	9	36	14	31	12	14	21	3	3	..	50	5	152	
Solanaceae	2	1	..	3	..	5	1	..	1	1	..	3	1	..	1	..	..	..	..	3	..	..	
Scrophulariaceae	3	..	2	34	10	18	15	..	15	7	16	5	52	5	18	10	17	..	..	38	11	126	
Orobanchaceae	..	..	1	8	..	4	8	..	4	..	..	3	13	1	..	..	..	..	..	9	..	4	
Gesneriaceae	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	
Lentibulariaceae	..	..	1	1	..	..	1	..	1	..	..	..	6	..	..	..	2	..	..	..	..	1	
Globulariaceae	..	..	..	..	..	..	1	..	..	1	1	..	3	..	..	1	1	..	..	..	..	1	
Acanthaceae	..	..	..	..	..	..	1	..	..	..	1	1	..	..	1	..	..	..	..	..	..	..	
Plantaginaceae	2	..	..	3	1	6	3	..	4	..	2	1	4	..	..	..	2	..	..	5	1	2	
Rubiaceae	..	..	2	5	2	11	12	1	4	2	16	2	29	7	5	5	1	..	..	21	2	52	
Caprifoliaceae	..	..	2	4	4	2	5	..	..	..	..	..	1	..	..	1	..	..	..	1	..	2	
Adoxaceae	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Valerianaceae	..	..	..	2	2	7	8	..	1	..	4	2	8	2	1	2	2	..	..	6	..	7	
Dipsacaceae	..	..	..	3	1	5	3	..	6	4	5	4	14	..	3	5	1	..	..	15	5	32	
Cucurbitaceae	..	..	..	..	..	1	1	..	..	1	1	1	2	..	..	..	..	..	..	2	..	..	
Campanulaceae	..	..	1	8	1	2	6	..	1	4	9	..	22	2	8	4	11	..	..	10	5	76	
Compositae	6	..	2	109	22	37	74	1	55	22	71	21	140	30	42	29	39	1	2	97	20	326	
Totals:																							
Gymnospermae	..	..	2	1	1	2	4	1	1	1	4	2	5	..	..	..	1	..	..	12	..	3	
Monocotyledoneae	68	20	81	143	33	134	122	16	42	15	24	44	126	21	27	36	62	3	2	189	42	163	
Dicotyledoneae	73	17	97	617	187	359	574	23	295	104	365	245	789	157	210	181	220	6	6	860	231	1588	
Totals for all classes	141	37	180	761	221	495	700	40	338	120	393	291	920	178	237	217	283	9	8	1061	273	1754	

the number of species of these families in the Balkan Peninsular Flora. Those contributed are mostly weeds and ruderals.

A glance over the distribution tables for the species certainly conveys the impression that those species with a wide general distribution have for the most part a wide distribution within the Balkan Peninsula. To test this in figures the 'wides' in three families were taken and their distribution in the various districts of our area summarized with the following results. In the first column is given the number of species occurring in only one district, in the second the number known from two districts, and so on.

Districts:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Cyperaceae .	10	9	8	4	3	4	7	6	3	6	5	5	2	5	1	2	..	1	2	..	1	1	..	..	..
Ranunculaceae .	4	2	2	3	2	1	4	6	3	1	2	2	2	..	2	1	1	1	1	..	..	..	..	..	1
Labiatae . .	1	1	1	..	2	1	..	1	2	2	2	3	1	1	3	2	2	2	2	2	4	2	..	1	..

It is worth contrasting these figures with those obtained by summing the distributions for the endemic species in the *Ranunculaceae* and *Labiatae*. There are only 2 endemic species of *Cyperaceae*, an insufficient number from which to draw any conclusions.

Districts:	1	2	3	4	5	6	7	8	9	10
Ranunculaceae . .	22	5	6	2	..	..	..	..	1	1
Labiatae . . .	84	25	11	11	10	3	5	1	1	1

It thus appears that the widely distributed species of the *Cyperaceae* are in the Balkan Peninsula much more local than might be expected, but that those of the *Ranunculaceae* and still more the *Labiatae* are on the average widely dispersed in our area. The last fact is particularly emphasized by comparison with the distribution of the endemics, the great majority of which show a very narrow distribution within the Balkan Peninsula.

It is difficult or impossible with our present available data to suggest when or whence most of the 'wides' entered the Balkan Peninsula. The question is largely beyond the limited scope deliberately set for this work. A certain number of those listed under III. probably extended from Central Asia and entered our area from the north-east at different periods. Others of the same origin probably extended across Asia Minor and thence into the Balkan Peninsula. Thus Limpricht,[1] recognizing 416 species of *Pedicularis*, indicates a migration route from the main centre of dispersal in Central Asia directed south of the Caspian Sea across northern Asia Minor, with lateral branches, and thence through the northern parts of the Balkan Peninsula to the

[1] *Fedde Repert*, xx. 161 (1924).

Alps and westwards of these. Some species essentially tropical or subtropical spread into the Mediterranean domain from the south, or south-east, or south-west. Yet others may, as species, be the result of hamagenesis.[1]

SPECIES OF THE BALKAN PENINSULAR FLORA HAVING A GENERAL DISTRIBUTION THROUGHOUT MOST OF EUROPE, EXCEPTING SOMETIMES THE EXTREME NORTH (IV.).

This group of 220 species is not of special interest. It appears to be largely composed either of essentially Central European species which have spread southwards into the mountains and again northwards after the Ice Age, or of species which are relicts of a formerly more widely spread species or type.

SPECIES OF THE BALKAN PENINSULAR FLORA HAVING A DISTRIBUTION THROUGHOUT MOST OF THE MEDITERRANEAN REGION (V.).

The phrase 'Mediterranean Region' is used here in a broad botanical sense to include both the Mediterranean Basin proper and the eastern countries accepted at Kew as 'the Orient', that is from Asia Minor eastwards to Persia, Afghanistan, and Beluchistan, and southwards to Arabia. The categories VI. to XI. are special subdivisions for Mediterranean species of more limited distribution. The species extending through the whole or a great part of the Mediterranean Botanical Region, in the wide sense as defined above, number 495, and are therefore exceeded in number by the 700 species limited to the countries bordering the Mediterranean Sea but extending into most of them. With the origins of the Mediterranean flora we are not here concerned. The subject is certainly a difficult one and has never been adequately investigated. That many species have had an Oriental origin or ancestry is certain, and that many, probably a majority, have originated as species within the Mediterranean Region itself is practically

[1] The term *hamagenesis* (ἅμα, at the same time, and γένεσις, origin) indicates evolutionary changes in a whole species or a mass of individuals of a species at approximately the same time, as contrasted with evolution by changes occurring in one or a few individuals and, by multiplication and spread of these, the occupation of an increasing distributional area by a new species. No suggestions are included as to the causes of the changes. The idea is an old one and is related to Saporta's conception of 'cantonnement', to Guppy's theory of 'differentiation', to Bateson's suggestions of 'fractionization', to the various records of simultaneous, repeated, and mass mutations, to environmental and food effects on a population, and to other views of the static or *in situ* origin of floras or parts of floras. Stefanoff in monographing *Colchicum* (in *Svorn. Balg. Akad. Nauk.*, xxii, 1926) has used the term *syngenesis* with essentially the same significance, but unfortunately this has already been used in quite a distinct connexion with a totally different meaning. The underlying idea of hamagenesis has also been clearly formulated by zoologists, as by L. S. Berg in his work on Nomogenesis (see *Nature*, 30 Oct., 1926).

certain. Moreover the evidence derivable from geographical distribution shows that the Balkan Peninsula itself has been an important centre of species formation and dispersal, contributing largely to the Mediterranean Flora. Dealing, as we mainly are in this work, with the species as a unit the floristic linkages become clearer with species having the more limited general distributions. Nevertheless, since the Balkan Peninsula exhibits the two climatic types known as Central European and Mediterranean, it will be well to indicate the floristic importance of the Mediterranean contribution to its flora by totalling the species included in categories V. to XI. inclusive. We thus find 2,377 species are 'Mediterranean', excluding the endemics and Balkan Peninsular types.

To the totals of Mediterranean Regional species the following families contribute each 15 or more species: *Gramineae* (66), *Cyperaceae* (16), *Liliaceae* (20), *Caryophyllaceae* (15), *Cruciferae* (26), *Leguminosae* (58), *Umbelliferae* (23), *Borraginaceae* (18), *Scrophulariaceae* (18), and *Compositae* (37).

The following families contribute most 'Mediterranean' species as a whole, i.e. with a distribution within but not always throughout the Mediterranean Region in the broad sense, and excluding endemics and Balkan Peninsular types: *Gramineae* (150), *Liliaceae* (95), *Orchidaceae* (49), *Caryophyllaceae* (121), *Ranunculaceae* (65), *Cruciferae* (135), *Rosaceae* (64), *Leguminosae* (317), *Umbelliferae* (123), *Borraginaceae* (58), *Labiatae* (119), *Scrophulariaceae* (76), *Rubiaceae* (48), and *Compositae* (281).

The second list probably gives the more accurate idea of the chief families occurring in the Mediterranean domain of the Balkan Peninsula. The predominance of *Leguminosae* is noteworthy, and the high numbers for *Compositae*, *Gramineae*, and *Cruciferae* indicate the most characteristic families.

Relative to northern and Central Europe the Mediterranean Region, within the latest geological epochs, has had stable climatic conditions, certainly without any of the dynamic changes occasioned by the Ice Age to the north, during its existence, its on-coming, its out-going, and its fluctuations. Hence the extension or migration of species has been, within geologically recent times, largely unbroken, but more gradual and on a less extensive scale relative to the whole flora than in the extra-Mediterranean parts of Europe, excluding, of course, the important effects of the human factor. The Mediterranean flora, as a whole, is older than the Central European, although this statement does not necessarily apply to the individual component species, nor until account has been taken of the influence of man. But we may certainly say that it has a basis or core which is older.

SPECIES HAVING A WIDE DISTRIBUTION WITHIN THE MEDITERRANEAN BASIN (VI.).

These species, totalling 700 for the Balkan Peninsula, are typical Mediterranean plants in whatever sense the word is used. They extend often right through the Mediterranean Basin from Spain to Asia Minor, Syria, and Palestine, and most often occur in North Africa as well. It is probable that as species most of them have originated in the area, and possibly a fairly considerable number have had a hamagenetic origin. Families contributing more than 30 species are: *Gramineae* (32), *Liliaceae* (33), *Caryophyllaceae* (41), *Cruciferae* (38), *Leguminosae* (119), and *Compositae* (74).

The number of species which, though essentially Mediterranean (V. or VI.), occur in Western Europe, north of the Mediterranean domain, but not in Central Europe proper, is noteworthy. I have not specially studied this question, but the species represented in the Balkan Peninsular Flora which have essentially this distribution number at least 50. A full analysis of the species common to Western Europe and parts, or all, of the Mediterranean Botanical Region would yield some interesting results as is already indicated by Stapf's paper on 'The southern element in the British flora'.[1] There is no doubt about the Carpathians, Alps, and Pyrenees being barriers of first-class importance, and the migrations of southern plants to Western Europe, via South France, or via lost Atlantic land, needs detailed consideration. That many Mediterranean species can flourish in Western Europe and under oceanic climatic conditions is perfectly well known, and I have personally proved it for a number of species by experiments in the Herbarium Experimental Ground at Kew. It is also known that the flora of the Central European lowlands is much poorer than it should be on the basis of existing climatic conditions alone. Hence the importance of studying barriers to migration, and also palaeometeorology, in attempting to investigate the history of the European flora.

SPECIES WITH CENTRES OF DISTRIBUTION IN THE WESTERN MEDITERRANEAN BASIN (VII.).

The total number of species under this heading which reach the Balkan Peninsula is only 40, contrasting with the 394 species centred around the eastern Mediterranean Basin and the 289 Oriental ones. This is one line of evidence which indicates that the rich flora of the Balkan Peninsula owes more to the east than to the west. Since the species concerned are few it will be well to list those with the sole

[1] *Engler's Bot. Jahrb.* l, Suppl. 509 (1914).

distribution of VII., with their Balkan Peninsular distribution given in the figure-symbols used throughout this work.

Pinus pinaster Soland. 14, 16.
Aira cupaniana Guss. 1.
Ampelodesmos tenax Link 2, 16.
Arrhenatherum erianthum Boiss. et Reut. 8a.
Catapodium tuberculosum, Moris 2.
Chaeturus fasciculatus Link 14.
Glyceria spicata Guss. 11.
Lygaeum spartum L. 1.
Vulpia broteri Boiss. et Reut. 2, 2a, 3b.
Narcissus pseudonarcissus L. (and extending north in Western Europe) 11, 14.
Aceras longibracteata Reichb. 1, 2, 2a, 14.
Ophrys scolopax Cav. 16.
Silene coeli-rosa A. Br. 5, 14.
Astragalus sesameus L. 11, 12, 13, 14, 15, 16.
Coronilla valentina L. 5, 14.
Lotus hispidus Desf. 12.
Lupinus luteus L. 2.
Medicago intertexta Mill. 2, 4a.
Trifolium isthmocarpum Brot. 7.
Euphorbia spinosa L. 5, 11, 13, 14, 16.
Tamarix gallica L. 9, 11, 14 (and extending north in Western Europe).
Helianthemum retrofractum Pers. 1.
Oenanthe globulosa L. 14.
Erica multiflora L. 14.
Anagallis tenella L. 1, 4a (and extending north in Western Europe).
Armeria plantaginea Willd. 14.
Phillyrea angustifolia L. 5, 14.
P. latifolia L. 4, 5, 11, 13, 14, 15, 16.
Convolvulus nitidus Boiss. 8b.
C. tricolor L. 2, 6a, 7, 14.
Teucrium fruticans L. 14.
T. marum L. 14.
Galium tenellum Jord. 11.

The genus *Cistus* is a good example of a genus with its chief centre in the western Mediterranean Basin. Eleven of the 16 species occur in the Iberian Peninsula and only 4 in our area. Of these last: *C. villosus* L. does not occur in Spain or Portugal, but is distributed from Morocco and Algeria to Corsica, Sicily, Sardinia, central and south

Italy, and the Balkan Peninsula to western Asia Minor, Syria, and Palestine; *C. parviflorus* Lam. also is not known from the Iberian Peninsula but occurs in Tunis, Sicily, Crete, Greece, Thrace, western and southern Asia Minor, and Cyprus; *C. salviifolius* L. has a very wide distribution through the Mediterranean Region from the Iberian Peninsula to Asia Minor, Transcaucasia, and Azerbaijan; and *C. monspeliensis* L. is known from the Atlantic islands, north-west Africa, the Iberian Peninsula, southern France, Italy and near-lying islands, the Balkan Peninsula, and Cyprus; *C. laurifolius* L. has a disconnected distribution, occurring in the Iberian Peninsula and north-west Africa and again from Bithynia to Cilicia, but not in the Ligurian-Tyrrhenian area or Balkan Peninsula. The genus *Cistus* is essentially Mediterranean and its species are important constituents of the macchie and allied plant communities. Some genera have distribution centres in the Iberian Peninsula but do not extend eastwards to reach the Balkan Peninsula at all. A typical instance is *Ulex*.

It has already been stated that geologically the greater part of Italy is much younger than either the Balkan Peninsula or Spain. It is therefore of interest to give a list of species which occur in the Balkan and Iberian Peninsulas but not in the Italian or in Sicily. It must be understood that the majority of these species are not solely or essentially western Mediterranean outside the Balkan Peninsula. Many occur also east of our area and in North Africa. That they miss Italy is certainly an indication of a considerable age for many of them, though polygenesis or polytopy may account for the present distribution of a few of them as species.

SPECIES OCCURRING IN THE BALKAN PENINSULA AND WEST OF ITALY BUT NOT IN THE ITALIAN PENINSULA OR IN SICILY.

Hyacinthus amethystinus L.
Arceuthobium oxycedri Bieb.
Mollugo cerviana Ser. (adventive in a few places in Italy).
Cerastium dichotomum L.
C. perfoliatum L.
Queria hispanica L.
Saponaria glutinosa Bieb.
Ranunculus demissus DC.
Hypecoum pendulum L.
Roemeria hybrida DC. (adventive near Genoa).
Alyssum linifolium Stephan
Reseda jacquinii Reichb.
Prunus prostrata Labill.
Astragalus lusitanicus Lam.
A. stella Gouan
Lupinus hispanicus Boiss. et Reut.
Malva aegyptia L.
Sida sherardiana (Jaub. et Spach).
Helianthemum umbellatum Mill.
Elaeagnus angustifolia L. (adventive in a few places in Italy).
Rhododendron ponticum L.
Convolvulus nitidus Boiss.
Lithospermum tenuiflorum L. fil.
Lycopsis orientalis L.
Myosotis refracta Boiss.

Lycium barbarum L.
Sibthorpia europaea L.
Scutellaria orientalis L.
Scabiosa sicula L. (doubtfully from Sicily).
Wahlenbergia hederacea Reichb.

The old relationship between the floras of Spain and the Balkan Peninsula is further emphasized by the occurrence of pairs of allied species of the same genus in the two areas. Often neither of the species occurs in Italy. The following is a list of examples:

Spain.	*Balkan Peninsula.*
Merendera montana Lange	*M. attica* Boiss.
Arenaria nevadensis Boiss.	*A. conferta* Boiss.
Buffonia willkommiana Boiss. }	*B. stricta* Gürke
B. macropetala Willk. }	
Thalictrum tuberosum L.	*T. orientale* Boiss.
Potentilla nivalis Lapey.	*P. haynaldiana* Janka
Prunus lusitanica L.	*P. laurocerasus* L.
Ruta rosmarinifolia Pers.	*R. coronatum* Griseb.
Hypericum coris L.	*H. empetrifolium* Willd.
H. fimbriatum Lam.	*H. transsilvanicum* Čelak.
Viola cazorlensis Gandoger	*V. delphinantha* Boiss.
V. cornuta L.	*V. nicolai* Pant. *V. orphanidis* Boiss. *V. speciosa* Pant.
Daucus durieua Lange	*D. involucratus* S. et S.
Freyera bunioides (Boiss.)	*F. macrocarpa* Boiss. et Spr. *F. cretica* Boiss. et Heldr.
Erica vagans L.	*E. verticillata* Forsk.
Nonnea alba DC.	*N. ventricosa* Griseb.
Phlomis lychnitis L.	*P. fruticosa* L.
Ramondia pyrenaica Rich.	*R. serbica* Panč. *R. nathaliae* Panč. et Petrov.
Jasione foliosa Cav.	*J. bulgarica* Stoy. et Steff.

It is very probable that many of the above pairs of species, or groups of species, represent examples either of hamagenesis or at least of fractionization of some Tertiary common ancestral type. They must, however, be considered as examples of pseudovicarism. A corresponding example is that of *Smilax excelsa* L., which is essentially a Pontic species occurring in the western parts of the Balkan Peninsula, where I have seen it forming liane-like festoons over trees and shrubs, and *S. divaricata* Solander ex Stapf of the Azores.[1] *Dioscorea balcanica* Košanin is closely related to *D. caucasica* Lipsky and has no close

[1] See *Bot. Mag.* t. 9067 (1925).

taxonomic affinity with *D. pyrenaica* Bub. et Bordère from the Pyrenees, which, indeed, has been by some taxonomists placed in another genus, *Borderea*.

Willkomm [1] gives a list of 40 species for Spain, which are designated 'orientalischen (in Arabien, Palästina, Syrien, Kleinasien, Armenien, Mesopotamien, Persien heimischen)'. I have investigated the detailed distribution of these only for the Balkan Peninsula, in which 18 of them occur, leaving 22 which extend through the Mediterranean Basin or Mediterranean Region but miss the Balkan Peninsula. Many, probably most, of these last have extended along North Africa and for some the route can be partially traced by their existing distribution. But it must be remembered that the evidence is very strong that there have been considerable, and floristically important, climatic changes in North Africa within geologically recent times, and these have certainly resulted in discontinuity of distribution for various species. Willkomm also lists 8 Spanish species as 'innerasiatischen Arten', and of these 6 are not known to occur in the Balkan Peninsula.

A considerable number of genera are represented by a fair or large number of different, and often endemic, species in the Balkan and Iberian Peninsulas respectively. Among these the following are especially noteworthy: *Colchicum*, *Dianthus*, *Silene*, *Astragalus*, *Cytisus*, *Genista*, *Ruta*, *Hypericum*, *Viola*, *Bupleurum*, *Convolvulus*, *Anchusa*, *Salvia*, *Teucrium*, *Thymus*, *Celsia*, *Digitalis*, *Linaria*, *Verbascum*, *Veronica*, *Orobanche*, *Asperula*, *Galium*, *Campanula*, *Centaurea*, *Cirsium*, *Crepis*, *Helichrysum*, and *Jurinea*. For the section *Epitrachys* of *Cirsium* Petrak [*Bibl. Bot.* Heft 78 (1912)] accepts 6 species for the Iberian Peninsula, 6 for Italy, and 12 for the Balkan Peninsula. He suggests that the stem-type of this section entered Europe from the south-east, from Asia, and spread thence north and west. The genera listed above, and others, certainly appear to have had two foci of species development in the Balkan and Iberian Peninsulas respectively.

It will be of interest here to make a further comparison of the flora of Spain with that of the Balkan Peninsula. In his 'Grundzüge der Pflanzenverbreitung auf der iberischen Halbinsel' [2] Willkomm gives the total species for 'die spontane Flora der iberischen Halbinsel' as 5,660, presumably including the Vascular Cryptogams with the Phanerogams. In Willkomm et Lange, *Prodromus Florae Hispanicae* (1861–80), the Gymnosperms and Angiosperms total 5,026 species. In Lázaro é Ibiza: *Compendio de la Flora Española* (1906–7), which includes neither Portugal nor the Balearic islands, the number of

[1] Grundzüge der Pflanzenverbreitung auf der iberischen Halbinsel, in *Engler und Drude: Die Vegetation der Erde*, i (1896).

[2] *Engler und Drude: Die Vegetation der Erde*, i. 103 (1896).

species of Phanerogams is 5,478, after deducting the cultivated plants and accepting the aliens on the same restricted basis as I have done for my Balkan Peninsular studies. Comparing the Phanerogams recorded from Spain in the above works with those known from the Balkan Peninsula I have found that 2,340 species are common to the two areas. Since I have not studied the flora of Spain in the special manner I have that of the Balkan Peninsula this number is an approximation, though of sufficient accuracy to indicate the common specific basis of the two floras. There are bound to be differences in accepted standards of species between works by different authors, dealing with different geographical areas, and written at different times. Probably these differences are not great here, and the conclusion I have reached is that the floras of the Iberian and Balkan Peninsulas contain very nearly the same number of species, but that the latter is slightly the richer in this respect.

SPECIES HAVING A SOUTH EUROPEAN DISTRIBUTION (VIII.).

These total 338, but they are not all limited to this distribution. Essentially they are Mediterranean but some are mountain plants with discontinuous distribution. The families contributing 15 or more species are: *Gramineae* 15, *Caryophyllaceae* 20, *Cruciferae* 22, *Leguminosae* 43, *Umbelliferae* 26, *Labiatae* 21, *Scrophulariaceae* 15, and *Compositae* 55.

CONNEXIONS WITH THE FLORA OF ITALY (IX.).

The geological history of the Adriatic Sea has been dealt with elsewhere (p. 24). It is certain that the greater part of Italy is geologically of Tertiary age, and much of it young Tertiary, but it is possible that its eastern part was formerly joined with the Balkan Peninsula previous to the late formation of the Adriatic Sea. The flora of Italy is correspondingly poorer, especially in old endemic and relict species than that of the Balkan Peninsula. A number of species common to the Balkan Peninsula and the western Mediterranean countries miss Italy entirely (see p. 365). Apart from these facts the floras of the western parts of the Balkan Peninsula and of eastern Italy show considerable affinities. A number of species which are essentially western Mediterranean in their general distribution occur in Italy and reach their eastern limits on the Adriatic slopes of the Balkan Peninsula. Others, as *Chamaerops humilis* L., do not reach the Balkan Peninsula from the west. Other species, essentially eastern Mediterranean or Oriental in their general distribution, extend across the Balkan Peninsula to reach their western limits in Italy. A still greater number, however, have never been recorded west of our area.

With species of wide distribution it is difficult to trace probable lines of extension with any degree of certainty, at least without detailed monographic research on entire genera. Hence it will suffice here to give a list (probably fairly complete) of species common to Italy and the Balkan Peninsula and apparently limited to these areas, and selected examples of species probably indicating direct connexions between the floras of the two areas, but not limited to them.

SPECIES COMMON TO ITALY AND THE BALKAN PENINSULA, AND APPARENTLY LIMITED TO THESE AREAS.

Pinus leucodermis Ant.
Aegilops uniaristata Vis.
Avenastrum convolutum Hal.
Poa bivonae Parl.
P. silvicola Guss.
Trisetum myrianthum Parl.
Carex macrolepis DC.
Allium cyrillii Ten.
Colchicum bivonae Guss.
Ornithogalum collinum Guss.
O. kochii Parl.
Iris cengialtii Ambrosi.
Quercus macedonica Griseb.
Parietaria cretica L.
Thesium parnassi DC.
Rumex triangularis DC.
Dianthus ciliatus Guss.
Herniaria rotundifolia Vis. (possibly only a var. of *H. glabra* L.).
Saponaria calabrica Guss.
Silene roemeri Friv.
Tunica rigida Boiss.
Corydalis ochroleuca Koch.
Alyssum leucadeum Guss.
Arabis nivalis Guss.
Barbarea bracteosa Guss.
B. sicula Presl.
Brassica incana Ten.
Cardamine chelidonia L.
C. glauca Spreng.
Hesperis glutinosa Vis.
Ptilotrichum rupestre Boiss.
Ribes multiflorum Kit.
Saxifraga glabella Bert.
Potentilla apennina Ten.
Rosa heckeliana Tratt.
Cytisus spinescens Presl.
Genista dalmatica Bart. et Wendl.
Lathyrus grandiflorus S. et S.
Lupinus cosentinii Guss.
Onobrychis laconica Orph.
Trifolium tenuifolium Ten.
Geranium brutium Gasp.
G. reflexum L.
Linum capitatum Kit.
Euphorbia barrelieri Savi.
Althaea rosea Cav.
Danaa verticillata Janchen (also from Algeria ?).
Freyera cynapioides Griseb.
F. tuberosa Reichb. f.
Heracleum orsinii Guss.
Laserpitium garganicum Ten.
Oenanthe jordanii Ten.
Orlaya daucorlaya Murb.
Seseli tommasinii Reichb.
Trinia dalechampii Janchen.
Limonium cosyrense O. Kuntze.
Echium pustulatum S. et S.
Heliotropium bocconii Guss.
Solenanthus apenninus Hohen.
Ballota acuta Briq.
Lamium bifidum Cyr.
Marrubium incanum Desr.
Phlomis lanata Willd.
Salvia bertolonii Vis.

Stachys janianus Ces. Pas. et Gib.
Mandragora mas Gars.
Antirrhinum siculum Ucria.
Euphrasia liburnica Wettst.
Pedicularis friderici-augusti Tomm.
P. petiolaris Ten.
Verbascum densiflorum Bert.
V. macrurum Ten.
Globularia bellidifolia Ten.
Scabiosa cretica Cyr.
S. dallaportae Heldr.
S. garganica Porta et Riga.
S. holosericea Bert.
S. portae A. Kern.
Bryonia sicula Guss.
Campanula foliosa Ten.
C. marchesettii Witasek (to southern Carniola).
C. ramosissima S. et S.
C. versicolor Andrews.
Achillea barrelieri Schultz.
Adenostyles australis Nyman.
Anthemis guicciardii Heldr. et Sart.
Artemisia nitida Bert.
Carlina nebrodensis Guss.
Centaurea deusta Ten.
C. dissecta Ten. (also from Algeria?).
C. rupestris L.
C. tommasinii A. Kern.
Cirsium creticum Lam.
C. spathulatum Mor.
C. strictum Spreng.
Crepis bursifolia L.
C. columnae Froel.
C. rubra L.
Hieracium naegelianum Panč.
Hypochaeris cretensis L.
Leontodon fasciculatus Nyman (and from Algeria?).
Senecio bicolor Boiss.
Taraxacum glaciale E. et A. Huet de Pavillon.
Tragopogon eriospermus Ten.

SPECIES PROBABLY INDICATING DIRECT CONNEXIONS BETWEEN THE FLORAS OF THE BALKAN PENINSULA AND ITALY, BUT NOT LIMITED TO THESE AREAS.

Phleum graecum Boiss. et Heldr.
Juncus thomasii Ten.
Colchicum neapolitanus Ten.
Hyacinthus ciliatus Cyr.
Iris sintenisii Janka.
Quercus aegilops L.
Drypis spinosa L.
Minuartia graminifolia Jávorka.
Silene catholica Ait.
S. dichotoma Ehrh.
S. trinervia Seb. et Maur.
Tunica illyrica Fisch. et Mey.
Helleborus multifidus Vis.
Ranunculus asiaticus L.
R. neapolitanus Ten.
R. brutius Ten.
Papaver pinnatifidum Moris.
Berteroa mutabilis Vent.
Cardamine graeca L.
Lepidium hirtum DC.
Vesicaria graeca Reut.
Sedum magellense Ten.
Saxifraga marginata Sternb.
S. porophylla Bert.
Potentilla detommasii Ten.
Pyrus meridionalis Guss.
Rosa glutinosa S. et S.
Astragalus siculus Biv.
Glycyrrhiza echinata L.
Tetragonolobus biflorus Desr.

Trifolium brutium Ten.
T. praetutianum Guss.
Vicia ochroleuca Spreng.
V. sparsiflora Ten.
Euphorbia aleppica L.
Rhamnus intermedia Steud. et Hochst.
Althaea taurinensis DC.
Viola gracilis S. et S.
Bunium alpinum W. et K.
Carum multiflorum Boiss.
Lagoecia cuminoides L.
Torilis purpurea Guss.
Periploca graeca L.
Lamium garganicum L.
Majorana onites Benth.
Micromeria microphylla Benth.
Salvia triloba L.
Satureia cuneifolia Ten.
Scutellaria peregrina L.
Linaria dalmatica Mill.
Rhinanthus elephas L.
Pinguicula hirtiflora Ten.
Scabiosa silenifolia W. et K.
Asyneuma limonifolium Janchen.
Hedraeanthus graminifolius DC.
Anthemis brachycentros Gay.
A. chia L.
A. cretica Nyman.
Artemisia petrosa Jan.
Cardopatium corymbosum Pers.
Cirsium montanum Spreng.
Senecio cacaliaster Lam.

This second list does not pretend to be complete—it would be impossible to make it so at present. There are many species of general distribution V., VI., or VIII. which are common to Italy and the Balkan Peninsula, and very probably entered one from the other, the majority probably extending westwards. Other species of 'Alpine' distribution relative to the southern European peninsulas have extended into the Balkan Peninsula and into the Apennines along separate routes. A few species may be named which have entered the Italian and Balkan Peninsulas independently from different directions:

Festuca dimorpha Guss.
Thesium pyrenaicum Pourr.
Genista radiata Scop.
Linum flavum L.
Ruta patavina L.
Bupleurum aristatum Bartl.
Hladnikia golaka Reichb. f.
Micromeria thymifolia Benth.
Pedicularis summana Spreng.
Campanula morettiana Reichb.
Phyteuma halleri All.
Carduus carlinaefolius Lam.

It is of interest to consider specially the floristic relationships between the Gargano massif and the Balkan Peninsula. The peninsula of Gargano is just south of latitude 42° S., and is a mountain mass, chiefly of limestone, reaching to an altitude of 1,614 m. in Mt. Calvo. It is thus opposite to the Drin Gulf and just south of the marked line of shallowing of the Adriatic Sea and the string of small islands (Tremiti, Pianosa, Pelagosa) which link on to Cazza, Lagosta, and the other South Dalmatian islands. The peninsula of Gargano is accepted as of Mesozoic age and is thus much older than the surrounding areas,

which are mostly Pliocene. From the Apennines it is separated by a wide plain of Pliocene age with Foggia near the centre. The geological history of Gargano has been a matter of controversy, and though there is some evidence in favour of a late Tertiary land mass of 'Adria' or 'Adriatide' of which the Gargano Peninsula was a part, this is far from conclusive (see p. 24). It is, however, certain that Gargano has floral constituents which show affinity with the Balkan Peninsular flora on the opposite shores of the Adriatic, and that, taken as a whole, these are more numerous than in any other part of Italy. Whether these Balkan Peninsular elements immigrated by means of land which later disappeared beneath the waters of the Adriatic, or whether wind, birds, and other dispersal agencies account for their presence across the stretch of sea is not established. The following plants show a floristic connexion between the Balkan Peninsular and Garganic floras, and it will be noted that the relationship especially concerns the Illyrian karst flora:

Haynaldia villosa Schur.
Asphodeline liburnica Reichb.
Carpinus orientalis Mill.
Ostrya carpinifolia Scop.
Aubrietia deltoides DC.
Coronilla juncea L.
Cytisus spinescens Presl.
Genista dalmatica Bartl. et Wendl.
Ruta divaricata Ten.
Euphorbia barrelieri Savi.
Danaa verticillata Janchen.
Thapsia garganica L.
Coridothymus capitatus Reichb.
Lamium garganicum L.
Marrubium incanum Desr.
Satureia cuneifolia Ten.
Stachys recta L. var. *fragilis* Boiss.
Scabiosa crenata Cyr.
Anthemis brachycentros Gay.
Doronicum cordatum Schultz.
Inula verbascifolia Hausskn.
Phagnalon graecum Boiss. et Heldr.

Fiori has pointed out[1] that the Dalmatian connexions shown by the Garganic flora are entirely absent from the woodland flora. They occur among the cliff, rock, and bare plateau plants, which are often of a calcicolous nature.

Between Gargano and the opposite coast of the Balkan Peninsula, or, more exactly, the South Dalmatian islands, are a number of islets forming a line stretching in a north-east direction. This line is formed by the Tremiti, Pianosa, and Pelagosa islets across to Cazza, Lagosta, Curzola, and the Peninsula of Sabbioncello. Béguinot[2] has considered very fully the vegetation of the Tremiti islets together with that of Pianosa and Pelagosa. He states that of the 444 species indigenous to or thoroughly naturalized in these islets 376 or 84 per cent.

[1] Flora nemorale e boschi del Gargano, *Ann. del R. Instit. Super. Forestale Nazionale*, i. 1914–15 (1916).

[2] *Mem. di Mat. e di Fisica della Soc. Ital. delle Scienze*, xvi. 155 (1910).

are common to Gargano and to Dalmatia. Twenty-six species, several varieties, and one subspecies are common to them and Gargano, but are unrecorded for Dalmatia. The following occur in the islets mentioned and in Dalmatia, but not in Gargano: *Milium effusum* L., *Carex distachya* Desf., *C. halleriana* Asso, *Laurus nobilis* L., *Brassica incana* Ten. var. *mollis* (Vis.), *Ranunculus chius* DC., *Fumaria flabellata* Gasp., *Rubus ulmifolius* Schott var. *dalmatinus* (Tratt.), *Lotus cytisoides* L., *Melilotus elegans* Salzm., *Vicia hirsuta* S. F. Gray, *Peucedanum oreoselinum* Moench, *Convolvulus cneorum* L., *Orobanche caryophyllacea* Sm., *Crucianella latifolia* L., *Centaurea ragusina* L., and *C. fridericii* Vis. Fourteen species and one variety occur in the islets, but neither in Gargano nor in Dalmatia. That a former land connexion occurred, within fairly recent geological times, between Dalmatia and Gargano, and that the string of islets represents a remnant of this, appears likely from the floristic data available, but the onus of proof must rest with the geologists, and these are far from agreement.

SPECIES WITH EXISTING CENTRES OF DISTRIBUTION IN THE EASTERN MEDITERRANEAN BASIN (X.) OR ORIENT (XI.).

The former of these total 394 and are largely limited to this category. Families contributing 15 or more species are: *Leguminosae* 67, *Umbelliferae* 20, *Borraginaceae* 21, *Labiatae* 36, *Scrophulariaceae* 16, *Rubiaceae* 16, and *Compositae* 71. The latter total 291 and are likewise largely limited to the one category. Families contributing 15 or more species are: *Liliaceae* 19, *Caryophyllaceae* 28, *Ranunculaceae* 19, *Cruciferae* 34, *Leguminosae* 16, *Compositae* 21. The two categories X. and XI. are mutually exclusive and the species with an eastern distribution from the Balkan Peninsula, excluding those accepted as Dacian, Pontic, Caucasian, or essentially Balkan Peninsular types, therefore number 685. These may be considered together.

Asia Minor is geographically the nearest Asiatic land to the Balkan Peninsula (Europa Minor). At the Bosporus and Dardanelles the two continents are separated by narrow streams of water. The Aegean Sea is dotted with strings and groups of islands and, as stated elsewhere, is geologically of very recent origin. Moreover the climatic conditions of western Asia Minor and the southern parts of the Balkan Peninsula are very similar, and the topographical and edaphic factors also agree in many details. It would therefore be expected that the floristic and vegetational similarities would be close; and we find that they are.

Two main directions of extension may be traced; the one northwestwards from Asia Minor to Thrace, South Bulgaria, and Macedonia; the other westwards from Asia Minor across the Aegean to Crete and

Greece. The former includes many Pontic and Caucasian types which are dealt with separately. Since, however, from our present standpoint they only form a part of the 'Oriental migration' they are in this section merged with other Anatolian species. The connexions between Asia Minor and the lands of Europa Minor across the Bosporus and Dardanelles will be first considered.

The following species of Asia Minor reach, so far as is known with certainty, only Thrace or the Thracian Islands in the Balkan Peninsula.

Alopecurus setarioides Gren. (possibly also from North Macedonia).
Colchicum micranthum Boiss.
Tulipa bithynica Griseb.
Orchis sepulchralis Boiss. et Heldr.
Quercus infectoria Oliv.
Aristolochia hirta L.
Minuartia erythrosepala Hand.-Mazz.
Silene chloraefolia Sm.
S. thymifolia S. et S.
Helleborus orientalis Lam.
Nigella orientalis L.
Erysimum pulchellum Boiss.
E. smyrnaeum Boiss. et Bal.
Poterium villosum S. et S.
Rosa lutea Mill.
Astragalus trojanus Steven.
Gonocytisus angulatus Spach.
Hedysarum varium Willd.
Lathyrus undulatus Boiss.
Onobrychis cana Hand.-Mazz.
Ononis decipiens Aznav.
Sophora reticulata (Freyn et Sint.).
Trifolium globosum L.
Hypericum bithynicum Boiss.
H. cassium Boiss.
H. confusum Vandas.
Ainsworthia byzantina Aznav.
Cyclamen hiemale Hildebr.
Rhazya orientalis A. DC.
Convolvulus pilosellaefolius Desr.
Symphytum orientale L.
Lavandula cariensis Boiss.
Nepeta orientalis Mill.
Salvia pinnata L.
Verbascum bithynicum Boiss.
V. lagurus Fisch. et Mey.
V. parviflorum Lam.
V. pycnostachyum Boiss. et Heldr.
Veronica pectinata L.
Globularia trichosantha Fisch. et Mey.
Campanula delicatula Boiss.
C. lyrata Lam.
Anthemis anatolica Boiss.
Cirsium polycephalum DC.
Inula auriculata Boiss. et Bal.
Lapsana peduncularis Boiss.
Senecio castagneanus DC.

The detailed distribution of most of the 47 species in this list indicates very clearly that extension has been across the Bosporus or Dardanelles. Yet, even in this list, some of the species may have had a distribution across land now sunk beneath the northern part of the Aegean Sea. *Rhazya orientalis*, for example, may be an old Tertiary relict in this sense.

The next list is of species which, judging from their present known geographical distribution, show floristic connexions between the

southern parts of our area and Asia Minor, across what is now the Aegean Sea. Reference should be made to those pages dealing with the present physiographical conditions and the geological history of this area (pp. 7, 23). In order to test several tentative conclusions the known limits of altitudinal zonation (F.) are given, as well as the Balkan Peninsular distribution (H.) for each species.

Species common to Crete, Greece, the Cyclades, and Thessaly, or to one or more of these districts, and Asia Minor or the Asiatic islands, or to both, and probably having extended westwards, or more rarely eastwards:

Juniperus drupaceus Labill. (F. 4. H. 2, 3).
Antinoria insularis Parl. (F. 4. H. 1).
Ventenata macra Bal. (F. 2. H. 2).
Lloydia graeca Endl. (F. 2 to 4. H. 1, 2, 2a, 3).
Crocus crewei Hook. f. (F. 4. H. 2, 2a).
Ophrys anatolica Boiss. (F. 3. H. 2a).
Orchis sancta L. (F. 2, 3. H. 2, 2a).
Agrostemma gracile Boiss. (F. 3. H. 3).
Arenaria graveolens Schreb. (F. 4. H. 1).
A. oxypetala S. et S. (F. 4. H. 1, 2).
Dianthus lilacinus Boiss. et Heldr. (F. 5b. H. 2, 3).
Minuartia thymifolia Bornm. (F. 1. H. 1).
Silene squamigera Boiss. (F. 4.? H. 2, 3).
Telephium orientale Boiss. (F. 4.? H. 1, 2, 3).
Delphinium tenuissimum S. et S. (F. 3, 4. H. 2).
Paeonia arietina Biv. (F. 4. H. 2).
Ranunculus asiaticus L. (F. 2. H. 1).
R. cadmicus Boiss. (F. 5c. H. 2).
Thalictrum orientale Boiss. (F. 2 to 4. H. 2).
Alyssum fulvescens S. et S. (F.? H. 2).
A. praecox Boiss. (F. 2 to 5b. H. 2).
Crenularia polygaloides Boiss. (F. 1. H. 2).
Erysimum creticum Boiss. et Heldr. (F. 3. H. 1).
Matthiola bicornis DC. (F. 2, 3. H. 2, 2a).
M. pumilio DC. (F. 1. H. 2a).
Cotyledon serrata L. (F. 2. H. 1).
Sedum confertiflorum Boiss. (F.? H. 2).
S. laconicum Boiss. et Heldr. (F. 4 to 5b. H. 2, 3).
Cotoneaster nummularia Fisch. et Mey. (F. 4. H. 1).
Cicer ervoides Fenzl (F. 4, 5a. H. 1, 2).
Hammatolobium lotoides Fenzl (F. 4, 5a. H. 2).
Lathyrus neurolobus Boiss. et Heldr. (F. 3. H. 1).

Lotus lamprocarpus Boiss. (F. 2. H. 1, 2, 2a).
Onobrychis cadmea Boiss. (F. 4. H. 2).
O. ebenoides Boiss. et Sprun. (F. 2 to 5a. H. 2).
Trifolium clypeatum L. (F.? H. 1, 2).
Trigonella balansae Boiss. et Reut. (F. 2. H. 1, 2, 2a).
T. cariensis Boiss. (F. 2, 3. H. 2).
Vicia microphylla Urv. (F. 2, 3. H. 2, 2a).
V. pinetorum Boiss. et Sprun. (F. 4. H. 2).
Biebersteinia orphanidis Boiss. (F. 5b. H. 2).
Erodium gruinum L'Hér. (F. 1, 2. H. 1, 2, 2a).
Euphorbia arguta Soland. (F. 2. H. 2).
Acer orientale L. (F. 3 to 5a. H. 1, 2, 2a).
Hypericum atomarium Boiss. (F. 2, 3. H. 2).
H. empetrifolium Willd. (F. 1 to 3. H. 1, 2, 2a, 3).
Tamarix smyrnensis Bunge (F. 2. H. 2).
Fumana aciphylla Boiss. (F. 5b. H. 3).
Viola heldreichiana Boiss. (F. 5a. 5b. H. 1).
Datisca cannabina L. (F. 4. H. 1).
Daphne sericea Vahl (F. 3 to 5c. H. 1).
Anthriscus tenerrima Boiss. et Sprun. (F. 3, 4. H. 2).
Caucalis tenella Delile (F. 3. H. 2).
Lecokia cretica DC. (F. 2 to 4. H. 1).
Pimpinella anisum L. (F. 2. H. 1, 2).
P. cretica Poir. (F. 2, 3. H. 1, 2, 2a).
Limonium ocimifolium O. Kuntze (F. 1. H. 2, 2a).
Jasminum humile L. (F. 3. H. 2).
Vincetoxicum canescens Willd. (F. 3. H. 1).
Convolvulus cochlearis Griseb. (F. 4. H. 2).
C. dorycnium L. (F. 2, 3. H. 1, 2, 2a).
C. oleaefolius Desf. (F. 1, 3. H. 1, 2, 2a).
Alkanna orientalis Boiss. (F. 2 to 4. H. 2, 2a).
Anchusa aspera Boiss. (F. 1, 2. H. 2, 2a).
Echium diffusum S. et S. (F. 1. H. 1, 2, 2a).
Lithospermum hispidulum S. et S. (F. 1. H. 1).
Omphalodes luciliae Boiss. (F. 4, 5a. H. 2).
Onosma frutescens Lam. (F. 3. H. 1, 2).
Symphytum anatolicum Boiss. (F. 3. H. 2a).
Phlomis lunarifolia S. et S. (F.? H. 2).
Scutellaria sieberi Benth. (F. 2 to 4. H. 1).
Stachys iberica Bieb. (F. 3. H. 2).
Cymbalaria longipes (Boiss. et Heldr.) (F. 1. H. 1, 2).
Verbascum lasianthum Boiss. (F. 3. H. 2a).
Crucianella imbricata Boiss. (F. 2, 3. H. 1).

C. macrostachya Boiss. (F.? H. 1).
Galium coronatum S. et S. (F. 5b. H. 2).
G. graecum L. (F. 2, 3. H. 1).
Rubia brachypoda Boiss. (F. 3. H. 1).
Bryonia cretica L. (F. 2, 3. H. 1, 2, 2a).
Campanula drabifolia S. et S. (F. 2, 3. H. 2, 3).
Achillea cretica L. (F. 2. H. 1).
Centaurea cadmea Boiss. (F. 4. H. 2).
Cephalorrhynchus glandulosus Boiss. (F. 3. H. 3).
Cirsium cynaroides Lam. (F. 3. H. 1, 2).
Crepis bithynica Boiss. (F. 5a, 5b. H. 3).
Crepis multiflora S. et S. (F. 1 to 3. H. 1, 2, 2a).
C. smyrnaea DC. (F. 4. H. 2).
Echinops viscosus DC. (F. 2. H. 1, 2, 2a).
Helichrysum orientale L. (F. 2. H. 1, 2, 2a).

This list of 90 species is not exhaustive, and consists only of those species whose general geographical distribution, relative to the Balkan Peninsula, is so limited as to make the direct floristic connexion with Asia Minor very evident. A very large number, not included above, are common to the two areas but have a wider general distribution of such a nature that the species concerned may have entered the Balkan Peninsula and Asia Minor independently, although the majority probably came from one to the other.

The next list is of species whose extension has been from Asia Minor to Bulgaria or Macedonia, most often via Thrace across the Bosporus or Dardanelles or across the northern parts of the old Aegean continent. On an 'Age and Area' basis these would have to be considered older within the Balkan Peninsula than those species named in the first list of this section. I know of no independent method of proving this. While some of the species show relatively continuous distribution others have a decidedly discontinuous type. A good example of the latter is afforded by *Phelipaea boissieri* Stapf, which occurs as a parasite on *Centaurea* near Gradsko on the Vardar in North Macedonia, about 60 km. north of the present Greek boundary. The species is known from Caria in the west to Persia in the east and Syria in the south. The nearest known locality to the Macedonian one is Kassan Oglu in Caria, a distance of about 750 km. It is probable that this wide gap is in part due to the sinking of Aegaeis.

The following species of Asia Minor have reached Bulgaria or Macedonia or both, usually via Thrace:

Juniperus excelsa Bieb. (F. 3, 4. H. 6, 6a, 7, 8b).
Aegilops speltoides Tausch (F. ?. H. 8b).

Sesleria phleoides Steven (F. 5b. H. 8, 8b).
Allium cilicicum Boiss. (F. 3. H. 8a).
Gagea dubia Terracciamo (F. ?. H. 7, 8, 8a, 8b).
Merendera caucasica Bieb. (F. 2, 3. H. 8, 8a).
M. sobolifera C. A. Mey. (F. 2, 3. H. 8, 8a, 8b).
Ornithogalum wiedmannii Boiss. (F. 3. H. 7, 8, 8a).
Scilla bithynica Boiss. (F. 2. H. 8, 8a).
Smilax excelsa L. (F. 2, 3. H. 6a, 6b, 7, 7a, 8, 8a).
Crocus pulchellus Herb. (F. 2. H. 6a, 6b, 7, 8a, 8b).
Iris mellita Janka (F. 2, 3. H. 6, 6a, 7, 8, 8a, 8b).
Thesium brachyphyllum Boiss. (F. 5b. H. 8).
Arenaria graeca Hal. (F. 5a, 5b. H. 2, 7a, 8b).
Dianthus calocephalus Boiss. (F. 4. H. 6, 7).
Silene fabaria S. et S. (F. 1. H. 2, 6a, 6b, 7).
S. lydia Boiss. (F. 2. H. 6, 6a).
Nigella elata Boiss. (F. 3. H. 6a).
Ranunculus constantinopolitanus Urv. (F. 3. H. 7, 8, 8a).
Aethionema buxbaumii Boiss. (F. 2, 3. H. 7, 8a).
Alyssum cephalotes Boiss. (F. ? H. 6b).
Berteroa samolifolia Hayek (F. 3. H. 6, 6a, 6b, 8, 8b).
Schivereckia dorfleri Bornm. (F. 5c. H. 6).
Reseda truncata Fisch. et Mey. (F. 3, 4. H. 6, 7).
Cicer montbretii Jaub. et Spach (F. 3. H. 7, 8a).
Cytisus smyrnaeus Boiss. (F. 3. H. 8b).
Genista anatolica Boiss. (F. 3, 4. H. 7, 8b).
G. involucrata Spach (F. 3. H. 7, 8, 8b).
Lotononis genistoides Spach (F. 2, 3. H. 7, 8b).
Lotus strictus Fisch. et Mey. (F. 2. H. 7, 8a).
Onobrychis hypargyrea Boiss. (F. 3. H. 6).
Ononis adenotricha Boiss. (F. 3. H. 8a, 8b).
Trifolium constantinopolitanum Ser. (F. 3. H. 7, 8a).
Polygala anatolica Boiss. et Heldr. (F. 2, 3. H. 6a, 7, 8a, 8b).
Hypericum rhodopeum Friv. (F. 3. H. 6, 6a, 6b, 7, 8, 8a, 8b).
Bupleurum sulphureum Boiss. et Bal. (F. 2. H. 8a).
Chaerophyllum byzantinum Boiss. (F. 2, 3. H. 7, 8, 8a, 8b).
Johrenia selinoides Boiss. (F. 3. H. 8, 8a).
Turgeniopsis foeniculacea Boiss. (F. 3. H. 8b).
Cyclamen coum Mill. (F. 2, 3. H. 7, 8, 8a).
Myosotis cadmea Boiss. (F. 3. H. 6, 6a, 7, 8b).
Salvia grandiflora Ettl. (F. 2, 3. H. 6a, 7, 8, 8a).
Stachys thirkei C. Koch (F. 3. H. 7, 8, 8a).
Teucrium cordifolium Čelak. (F. 3. H. 7, 8a).
Veronica chamaepitys Griseb. (F. 2, 3. H. 7, 8a).

Phelipaea boissieri Stapf (F. 2, 3. H. 6).
Galium floribundum S. et S. (F. 3. H. 6a).
G. longifolium S. et S. (F. 3. H. 7, 8).
Scabiosa cosmoides Boiss. (F. 2. H. 8a).
S. hispidula Boiss. (F. 3. H. 7, 8a, 8b).
Carduus olympicus Boiss. (F. 3. H. 8).
Centaurea aurea Ait. (F. 2, 3. H. 7, 8a).
Erigeron olympicus Schott et Kotschy (F. 5b. H. 8).
Lapsana adenophora Boiss. (F. 2, 3. H. 6a).

The above list of 54 species again is not exhaustive, but is sufficient to show that phytogeographically Asia Minor has important connexions with the Bulgarian and Macedonian floras.

The next list of 57 species supports the conclusions already reached that floristic connexions are traceable across the whole of the Aegean area, and further shows that some species may have entered our area from Asia Minor both into Thrace and into Greece, the Cyclades, or Crete.

Species of Asia Minor which have several points or a wide zone of distribution into the Balkan Peninsula or vice versa:

Cephalanthera cucullata Boiss. et Heldr. (F. 4. H. 1, 7).
Ophrys oestrifera Bieb. (F. 3. H. 1, 2, 7).
Orchis iberica Bieb. (F. 5b. H. 2, 3, 3b, 7).
Silene discolor S. et S. (F. 1. H. 2a, 7).
S. longipetala Vent. (F. 2, 3. H. 2, 7).
Tunica pachygona Fisch. et Mey. (F. 3. H. 3, 6a, 7).
Velezia quadridentata S. et S. (F. 3. H. 2, 2a, 6a, 7).
Ranunculus orientalis L. (F. 2, 3. H. 2, 2a, 3, 7).
Hypecoum pendulum L. (F. 2, 3. H. 2, 6, 6a, 7, 8a).
Alyssum foliosum Bory et Chaub. (F. 3, 4. H. 1, 2, 6, 6a).
A. micropetalum Fisch. (F. 3. H. 2, 6a).
A. smyrnaeum C. A. Mey. (F. 3. H. 2, 7).
A. suffrutescens Hal. (F. 3. H. 2, 4, 7).
A. umbellatum Desv. (F. 3. H. 2a, 6, 7).
Astragalus sinaicus Boiss. (F. 2, 3. H. 2, 2a, 6, 6a, 7).
Coronilla parviflora Willd. (F. 2, 3. H. 1, 2, 7).
Ebenus sibthorpii DC. (F. 2 to 4. H. 2, 3, 6b).
Hippocrepis biflora Spreng. (F. 3. H. 2, 6a).
Medicago globosa Presl (F. 2. H. 1, 2, 2a, 6a, 7).
Trifolium radiosum Wahlenb. (F. 2. H. 2, 6a, 6b, 7).
Trigonella caerulescens Hal. (F. 3. H. 2, 2a, 7).
T. spruneriana Boiss. (F. 3. H. 2, 7).
Vicia cuspidata Boiss. (F. 2, 3. H. 6a, 7).

V. salaminia Heldr. et Sart. (F. 2 to 4. H. 1, 2, 2a, 3, 7).
V. smyrnaea Boiss. (F. 3, 4. H. 2, 2a, 6, 7).
Ruta buxbaumii Poir. (F. 2, 3. H. 1, 7).
Euphorbia biglandulosa Desf. (F. 2 to 5a. H. 1, 2, 7).
E. cybirensis Boiss. (F. 2. H. 1, 7).
E. sibthorpii Boiss. (F. 2, 3. H. 2, 2a, 6, 6a, 7).
Cistus parviflorus Lam. (F. 2, 3. H. 1, 2, 7).
Daphne collina Sm. (F. 4 to 5b. H. 1, 2, 6b).
Bupleurum trichopodum Boiss. et Sprun. (F. 3, 4. H. 2, 2a, 6a, 7)
Stefanoffia daucoides Wolff (F. 4. H. 3, 6a, 8b).
Cyclamen indicum L. (F. 3. H. 1, 2, 6b).
Anchusa macrocalyx Hausskn. (F. 2 to 4. H. 2, 2a, 3, 6a, 7).
Echium elegans Lehm. (F. 1, 3. H. 1, 2, 2a, 7).
E. sericeum Vahl (F. 1. H. 1, 2, 2a, 7).
Lamium moschatum L. (F. 2, 3. H. 2, 2a, 7).
Micromeria myrtifolia Boiss. et Hohen. (F. 2. H. 2, 3, 7).
Phlomis samia L. (F. 3, 4. H. 2, 3, 6a, 6b).
Scutellaria sibthorpii Boiss. et Reut. (F. 4 to 5b. H. 2, 3, 6a, 7).
Sideritis lanata L. (F. 1, 2. H. 2a, 6a, 7).
S. remota Urv. (F. 3. H. 2, 6a, 7).
Teucrium divaricatum Sieber (F. 2 to 4. H. 1, 2, 2a, 3, 6b, 7).
Thymbra spicata L. (F. 2, 3. H. 1, 2, 2a, 7).
Verbascum pinnatifidum Vahl (F. 1. H. 2, 2a, 3, 6b, 7).
Plantago cretica L. (F. 3. H. 1, 2a, 7).
Asperula involucrata Bergr. et Wablenb. (F. 3. H. 3, 7).
Galium incanum S. et S. (F. 5c. H. 1, 2, 4, 6b).
Rubia olivieri Rich. (F. 2, 3. H. 1, 2, 7).
Valerianella hirsutissima Link (F. 2. H. 2, 7).
V. obtusiloba Boiss. (F. 2 to 4. H. 1, 2, 6a).
Anthemis pectinata Boiss. et Reut. (F. 4 to 5b. H. 2, 3, 7).
Centaurea spinosa L. (F. 1, 3. H. 1, 2, 2a, 7).
Crepis aspera L. (F.? H. 1, 7).
Jurinea consanguinea DC. (F. 2. H. 2a, 7, 8b).
Onopordon sibthorpianum Boiss. et Heldr. (F. 2, 3. H. 1, 2, 2a, 3, 6a).

The next list naturally follows from the above and consists of species of Asia Minor having a still wider distribution within the Balkan Peninsula:

Juniperus foetidissima Willd. (F. 5a, 5b. H. 2, 3, 4, 5, 6, 6b).
Ephedra campylopoda C. A. Mey. (F. 2, 3. H. 1, 2, 2a, 3, 4, 4a, 5, 6, 6a, 6b, 7, 11, 12, 13, 14).
Aegilops caudata L. (F. 2, 3. H. 1, 2, 2a, 3, 4a, 6a, 7).
A. comosa S. et S. (F. 2, 3. H. 2, 2a, 3, 6a).

A. cylindrica Host (F. 2, 3. H. 6, 7, 8, 8a, 9, 10, 16).
Avena clauda Dur. (F. 2, 3. H. 2, 7, 8a, 8b).
Briza spicata S. et S. (F. 2 to 4. H. 2, 4, 7, 8a).
Bromus alopecuroides Poir. (F. 3. H. 1, 2, 2a, 4a, 6a).
Arum orientale Bieb. (F. 2 to 4. H. 2, 2a, 6a, 7, 8a, 11, 13, 14).
Juncus alpigenus Koch (F. 4 to 5b. H. 3, 6, 8, 8b, 11).
Fritillaria pontica Wahlenb. (F. 2 to 4. H. 6, 6a, 6b, 7, 8, 8a, 8b).
Gagea amblyopetala Boiss. et Heldr. (F. 3. H. 2, 3, 6a, 7).
Ornithogalum boucheanum Aschers. (F. 2, 3. H. 6, 7, 8, 8a, 9).
O. fimbriatum Willd. (F. 2 to 4. H. 2, 6a, 7, 8).
O. nutans L. (F. 2 to 4. H. 1, 2, 3, 6, 6a, 6b, 7, 8b, 9, 10).
O. oligophyllum Clarke (F. 5b. H. 2, 3, 4, 5, 6, 7, 8).
Galanthus graecus Orph. (F. 4 to 5b. H. 6, 6a, 7, 8, 8a, 8b, 10).
Crocus chrysanthus Herb. (F. 4 to 5b. H. 2, 6, 6a, 7, 8, 8a, 8b, 9, 10).
Salix amplexicaulis Bory et Chaub. (F. 3 to 4. H. 2, 3, 6, 6a, 8, 8a, 11).
Quercus aegilops L. (F. 2 to 4. H. 1, 2, 2a, 4, 5, 7, 11).
Cerastium illyricum Ard. (F. 3. H. 1, 2, 2a, 3, 6a, 6b, 7, 8b, 14).
Dianthus corymbosus S. et S. (F. 2, 3. H. 3, 6, 6a, 7, 8, 8a, 8b, 10, 11, 12).
D. glutinosus Boiss. et Heldr. (F. 3. H. 2, 2a, 6, 7, 8b, 10).
D. haynaldianus Borb. (F. 3, 4. H. 3, 4, 5, 6, 6a, 7, 8a, 8b, 10).
D. pallens S. et S. (F. 2, 3. H. 2, 3, 4a, 6, 6a, 7, 7a, 8, 8a, 8b, 9, 10).
Minuartia garckeana Mattf. (F. 5b. H. 5, 6, 8, 8b).
M. globulosa Schinz et Thell. (F. 2 to 4. H. 1, 2, 3, 6a, 6b, 14).
Paronychia chionaea Boiss. (F. 4 to 5b. H. 1, 2, 3, 4, 5, 6, 6a, 8b).
Silene caesia S. et S. (F. 3 to 4. H. 2, 3, 4, 5, 7).
S. gigantea L. (F. 3, 4. H. 1, 2, 2a, 3, 4, 4a, 5, 6, 6a, 8, 8a, 8b, 10).
S. subconica Friv. (F. 1 to 3. H. 2, 3, 6, 6a, 7, 8, 8a, 8b, 9, 10, 13).
Delphinium subvelutinum Heldr. (F. 2, 3. H. 2a, 5, 6a, 7).
Paeonia peregrina Mill. (F. 3, 4. H. 5, 6, 6a, 7, 8, 8a, 9, 10, 11, 15, 16).
Ranunculus eriophyllus Koch (F. 2, 3. H. 2, 3, 4a, 6a, 7, 8a).
R. rumelicus Griseb. (F. 3, 4. H. 2, 3, 6, 6a, 7, 8, 8a, 10).
Arabis bryoides Boiss. (F. 5b, 5c. H. 2, 3, 5, 6, 6a, 6b, 7a).
Brassica cretica L. (F. 1 to 4. H. 1, 2, 2a, 4a, 6b).
Clypeola microcarpa Moris (F. 2, 3. H. 2, 2a, 6, 6a, 6b, 7, 14).
Fibigia eriocarpa Boiss. (F. 4. H. 2, 3, 4).
Isatis canescens DC. (F. 3, 4. H. 2, 6b, 8, 12, 14).
Lepidium spinosum L. (F. 2. H. 1, 2, 2a, 6a, 7, 7a, 8a).
Malcolmia chia DC. (F. 3. H. 1, 2, 2a, 3, 4a, 7, 14).
M. flexuosa S. et S. (F. 1. H. 1, 2, 2a, 4a, 5, 6b, 7).
Thlaspi ochroleucum Heldr. (F. 3 to 5b. H. 2, 3, 6a, 8, 8b, 10, 11).
Cotyledon chlorantha Hal. (F. 2, 3. H. 1, 2, 3, 4a, 11, 14).

Sedum grisebachii Heldr. (F. 2 to 4. H. 2, 3, 6, 6a, 6b, 7, 8, 8a, 8b, 14).
S. litoreum Guss. (F. 1 to 3. H. 1, 2, 2a, 3, 6a, 11).
S. sartorianum Boiss. (F. 4. H. 2, 3, 5, 6, 6a, 8, 8a, 8b, 9, 10).
Platanus orientalis L. (F. 2 to 4. H. 1, 2, 2a, 3, 5, 6, 6a, 6b, 7, 8a, 8b).
Amelanchier cretica DC. (F. 4 to 5a. H. 1, 2, 11, 13, 14).
Geum coccineum S. et S. (F. 5b, 5c. H. 5, 6, 6a, 8, 8b, 10).
Potentilla speciosa Willd. (F. 5a to 5c. H. 1, 2, 3, 4, 5, 11, 13, 14).
P. ternata C. Koch (F. 5b. H. 5, 6, 8b, 10, 11, 12, 13).
Astragalus angustifolius Lam. (F. 3 to 5c. H. 1, 2, 3, 4, 5, 6, 6a, 6b, 8, 8b, 10, 11, 14).
A. spruneri Boiss. (F. 3. H. 2, 2a, 3, 6, 6a, 7, 8, 8a, 8b, 9, 11).
Coronilla cretica L. (F. 2, 3. H. 1, 2, 3, 5, 6, 6a, 6b, 7, 8a, 8b, 11, 13, 14, 15, 16).
Cytisus tmoleus Boiss. (F. 3, 4. H. 5, 8, 10, 12, 14).
Genista acanthoclada DC. (F. 2, 3. H. 1, 2, 2a, 4a).
G. carinalis Griseb. (F. 2 to 4. H. 3, 6, 6a, 6b, 7, 8, 8b, 10).
G. depressa Bieb. (F. 5a to 5c. H. 6, 8, 8b, 10).
G. lydia Boiss. (F. 3. H. 2, 7, 8, 8a, 8b, 10, 11).
Laburnum caramanicum Benth. et Hook. f. (F. 3, 4. H. 2, 3, 4, 6).
Lotus aegeus Boiss. (F. 2, 3. H. 3a, 6, 6a, 7, 8, 8b).
L. peregrinus L. (F. 1, 2. H. 1, 2, 2a, 11).
Lupinus pilosus Murr. (F. 3. H. 2a, 4a, 7).
Onobrychis oxyodonta Boiss. (F. 4 to 5b. H. 3, 4, 5, 11).
O. pindicola Hausskn. (F. 5a. H. 2, 3, 4, 6, 6a).
Trifolium balansae Boiss. (F. 2, 3. H. 6a, 7, 10).
T. latinum Seb. (F. 4. H. 2, 3, 7, 8a).
T. physodes Steven (F. 2 to 4. H. 1, 2, 3, 4, 4a, 5, 6, 11, 14).
T. preslianum Boiss. (F. 2, 3. H. 7, 8a, 11).
Linum pubescens Russ. (F. 2 to 4. H. 1, 2, 3, 4a, 5).
Polygala supina Schreb. (F. 3. H. 5, 6, 7, 8, 8a, 10, 11, 12).
P. venulosa S. et S. (F. 2, 3. H. 1, 2, 2a, 6a, 8a, 8b).
Euphorbia acanthothamnos Heldr. et Sart. (F. 2 to 4. H. 1, 2, 2a, 4a, 6a, 6b).
E. apios L. (F. 3 to 5a. H. 1, 2, 3, 6a, 6b, 7, 8a, 8b).
E. herniariaefolia Willd. (F. 4 to 5a. H. 1, 2, 3, 4, 5).
Hypericum olympicum L. (F. 3, 4. H. 2, 3, 6, 6a, 6b, 7, 7a, 8, 8a, 8b).
Tamarix hampeana Boiss. et Heldr. (F. 2. H. 2, 4a, 6a).
T. pallasii Desv. (F. 1, 2. H. 1, 2, 3, 4, 5, 6, 6a, 7, 8a, 9).
T. parviflora DC. (F. 1 to 3. H. 1, 2, 2a, 3, 4a, 5, 6, 6a, 7, 13).
T. tetrandra Pall. (F. 2. H. 1, 2, 6a, 7, 8a).
Viola gracilis S. et S. (F. 3 to 5b. H. 2, 3, 4, 5, 6, 6a, 7a, 11, 13).

Bunium ferrulaceum Bert. (F. 3, 4. H. 1, 2, 6a, 7, 8a, 8b, 11, 13, 14, 15).
Bupleurum glumaceum S. et S. (F. 2, 3. H. 1, 2, 2a, 4a, 6a, 7, 8a).
B. gracile DC. (F. 1 to 3. H. 2, 2a, 3, 6a, 7, 8, 8a).
Carum multiflorum Boiss. (F. 3 to 5b. H. 2, 2a, 3, 4, 4a, 5, 6, 6a, 8b, 10).
Oenanthe angulosa Griseb. (F. 2. H. 2, 6, 6a, 6b, 7, 8, 8a, 10).
Scaligeria cretica Vis. (F. 2 to 4. H. 1, 2, 2a, 3, 4, 4a, 5, 6b, 14).
Scandix grandiflora L. (F. 3. H. 1, 2, 2a, 4, 6a, 6b, 7, 14, 15, 16).
S. macrorhyncha C. A. Mey. (F. 5a. to 5c. H. 1, 2, 3, 4, 6, 6a, 6b, 8a, 9, 11).
Erica verticillata Forsk. (F. 2, 3. H. 1, 2, 2a, 3, 4, 4a, 5, 6a, 6b, 7, 13, 14).
Lysimachia atropurpurea L. (F. 3. H. 2, 3, 4, 5, 6, 6a, 7, 7a, 8a, 8b, 14).
Acantholimon echinus L. (F. 4 to 5c. H. 1, 2, 4).
Armeria undulata Boiss. (F. 3 to 5b. H. 2, 3, 5, 6, 6a, 6b, 7, 8b).
Goniolimon collinum Griseb. (F. 3. H. 6a, 7, 8, 8a, 8b, 10).
Limonium graecum O. Kuntze (F. 1. H. 1, 2, 2a, 6a, 6b, 7, 8, 8a, 9, 10).
Diospyros lotus L. (F. 2, 3. H. 2, 7, 14, 15).
Centaurium turcicum Ronniger (F. 2, 3. H. 8, 8a, 9).
Gentiana bulgarica Vel. (F. 5b, 5c. H. 5, 6, 8, 8b, 10).
Marsdenia erecta R. Br. (F. 1 to 3. H. 1, 2, 2a, 3, 5, 6, 6a, 6b, 7, 8a, 8b, 11).
Periploca graeca L. (F. 2, 3. H. 1, 2, 4a, 5, 6a, 6b, 7, 8, 9, 11, 14, 15).
Vincetoxicum speciosum Boiss. et Sprun. (F. 2 to 5a. H. 2, 3, 6, 6a, 6b, 7a, 8b).
Convolvulus hirsutus Steven (F. 2, 3. H. 1, 2, 3, 4a, 6a, 6b, 7, 8a, 8b, 10).
Heliotropium hirsutissimum Grauer (F. 2. H. 1, 2, 2a, 3, 7, 8).
Myosotis idaea Boiss. et Heldr. (F. 2 to 4. H. 1, 2, 2a, 6, 6a, 6b, 7, 8, 8a, 11).
M. olympica Boiss. (F. 4, 5a. H. 2, 3, 4, 7a, 11).
Rindera graeca Boiss. et Heldr. (F. 4 to 5c. H. 2, 4).
Ajuga salicifolia L. (F. 2, 3. H. 7, 8, 8a, 9).
Calamintha exigua Hal. (F. 2 to 4. H. 1, 2, 2a, 3, 6a, 8, 8a, 8b).
Lamium bithynicum Benth. (F. 3, 4. H. 3, 4, 5, 6, 6a, 8, 8b, 10).
L. striatum S. et S. (F. 3, 4. H. 1, 2, 4, 5, 6, 6a, 6b, 7a).
Micromeria cristata Griseb. (F. 4, 5a. H. 5, 6, 6a, 8, 8b, 10).
M. juliana Benth. (F. 2 to 5b. H. 1, 2, 2a, 3, 4, 4a, 5, 6, 6a, 6b, 7, 11, 13, 14, 15).
Origanum hirtum Link (F. 2 to 4. H. 1, 2, 2a, 3, 4, 4a, 5, 6a, 6b, 7, 7a, 8, 14, 16).

Salvia argentea L. (F. 2, 3. H. 1, 2, 3, 4, 6, 8, 8b, 10, 14).
S. candidissima Vahl (F. 2 to 4. H. 2, 4).
S. triloba L. (F. 2 to 4. H. 1, 2, 2a, 4a, 7, 13).
Satureia cuneifolia Ten. (F. 3, 4. H. 2, 4, 5, 6a, 7, 11, 13, 14).
S. parnassica Heldr. et Sart. (F. 5b. H. 2, 3, 4, 6b, 11, 14).
Sideritis perfoliata L. (F. 4. H. 3, 4, 6b).
S. purpurea Talbot (F. 2, 3. H. 1, 2, 3, 4, 4a, 5, 6a, 11, 13, 14).
Stachys cretica L. (F. 2. to 4. H. 1, 2, 2a, 5, 6a, 7a).
S. spinulosa S. et S. (F. 2. H. 1, 2, 4a, 7, 11, 14).
Thymus zygioides Griseb. (F. 3. H. 6, 6a, 7, 8, 8a, 8b, 9, 10).
Celsia orientalis L. (F. 2, 3. H. 2, 2a, 6, 6b, 7, 8a, 8b, 13, 14).
Scrophularia heterophylla Willd. (F. 2, 3. H. 1, 2, 2a, 3, 4, 4a, 6, 7, 11, 13).
Acanthus spinosissimus Pers. (F. 2, 3. H. 1, 2, 2a, 3, 4, 4a, 5, 6, 6a, 6b, 7, 11, 13, 14, 15, 16).
Crucianella graeca Boiss. (F. 2 to 4. H. 2, 2a, 3, 6, 6a, 6b, 7, 8, 8a, 8b, 10).
Galium scabrifolium Hausskn. (F. 4. H. 2, 3b, 4, 5, 8b).
G. tenuissimum Bieb. (F. 2, 3. H. 6, 7, 8, 8a, 10).
Valeriana dioscoridis S. et S. (F. 4. H. 2, 3, 3a, 5, 6, 6a, 6b, 11).
Morina persica L. (F. 3 to 5a. H. 2, 3, 4, 6, 6a, 7, 8b).
Asyneuma limonifolium Janchen (F. 4 to 5a. H. 2, 3, 4, 4a, 5, 6, 7, 8, 8a, 8b, 10, 11, 12, 13, 14, 15).
Campanula phrygia Jaub. et Spach (F. 2 to 4. H. 3, 6, 6a, 6b, 7, 8a, 8b, 10).
Legousia pentagonia Thell. (F. 2. H. 1, 2a, 4a, 7).
Achillea grandifolia Friv. (F. 3 to 5b. H. 2, 3, 5, 6a, 6b, 8, 8b, 10).
Adenostylis orientalis Boiss. (F. 5b, 5c. H. 5, 6).
Anthemis auriculata Boiss. (F. 2, 3. H. 2, 2a, 6, 6b, 7, 8a).
A. brachycentros Gay (F. 2, 3. H. 2, 3, 4, 4a, 5, 6a, 7, 8b, 11, 12, 13, 14, 15, 16).
Anthemis tomentosa L. (F. 1. H. 2, 4a, 6a, 7).
Carduus argentatus L. (F. 2. H. 3, 6, 6a, 7, 8a).
C. leiophyllus Petrov. (F. 3 to 5a. H. 3, 6, 6a, 8, 8a, 8b, 9, 10).
Centaurea pinardii Boiss. (F. 2, 3. H. 2, 3, 6, 6a, 7).
Chamaepeuce mutica DC. (F. 2 to 4. H. 1, 2, 2a, 4a, 6b).
Cirsium afrum DC. (F. 3. 4. H. 2, 3, 4, 5, 6, 6a, 8, 8a, 8b, 10).
C. ligulare Boiss. (F. 4 to 5b. H. 5, 6, 6a, 6b, 8, 8a, 8b, 9, 10, 11).
Crepis neglecta L. (F. 2 to 4. H. 1, 2, 2a, 3, 4, 4a, 5, 6, 6a, 7, 11, 12, 13, 14, 15, 16).
C. reuteriana Boiss. (F. 2, 3. H. 2, 4a, 7).
Doronicum orphanidis Boiss. (F. 5a. H. 3b, 6, 8).

Echinops microcephalus S. et S. (F. 2, 3. H. 2, 3, 6, 6a, 6b, 7, 8, 8a, 8b, 10).
Helichrysum plicatum DC. (F. 5b. H. 3b, 4, 5, 6, 6a).
H. siculum Boiss. (F. 2 to 4. H. 1, 2, 2a, 4a, 7).
Hieracium pannosum Boiss. (F. 4 to 5b. H. 1, 2, 3, 4, 5, 6, 6a, 6b, 8, 8b, 10, 11, 12, 13).
Lactuca intricata Boiss. (F. 4 to 5a. H. 2, 3, 4, 5).
Matricaria tenuifolium Tuzson (F. 4. H. 3, 5, 6, 6a, 7, 8, 8b, 10, 10a, 11, 12, 13, 14, 15).
Phagnalon graecum Boiss. et Heldr. (F. 2. H. 1, 2, 2a, 3, 4a, 5, 7, 14).
Rodigia commutata Spreng. (F. 2. H. 1, 2, 2a, 3, 6a, 7, 8a, 8b).
Senecio aucheri DC. (F. 5b, 5c. H. 3, 5).
S. macedonicus Griseb. (F. 3, 4. H. 2, 3a, 8, 8a, 8b).

This long list of 160 species indicates that not only have the areas of the Balkan Peninsula nearest in geographical position to Asia Minor close floristic connexions with the opposite lands of the Aegean region, but also that an important and more widely spread element of the Balkan Peninsular flora is common to the two areas. It is convenient here to consider the deeper significance of the floristic connexions proved in this section. There are four reasonable possibilities.

1. That the species common to the east and west of the Aegean Sea have spread westwards.
2. That they have extended eastwards.
3. That they originated in the old Aegean continent, or its remnants, and spread eastwards and westwards.
4. That they are the result of hamagenesis or polygenesis.

It is easy to pick out individual species whose present distribution relative to the known geological facts supports each of these possibilities. Indeed, it seems very probable that just as species, as they have been accepted in this work, have not arisen solely by one method, so their distribution has not been uniform in time or space relative to their origin. Distribution is the result of a complex of causes which it is always difficult to analyse. In the main an extension or migration westwards, both specific and generic, seems to have been most important in the Aegean region. The majority of the plants listed are typically 'Mediterranean' and occur in the coastal, lowland, hill, or montane altitudinal zones. It may be stated that though the lists are not exhaustive the species are representative of the chosen categories and have been selected without *a priori* conceptions. The number of species with a wide eastern distribution which, however, do reach the Balkan Peninsula is considerable, and we have seen how some only just enter our area, others extend into several districts, and

others are widely spread. This 'Oriental migration' is of very wide significance for the Mediterranean flora and even for that of Central Europe, especially the eastern parts. We have already recognized phases of it as Pontic and Pannonian, and the section on Caucasian connexions deals with another phase. A corresponding westward extension and migration has been established for various groups of vertebrate and invertebrate animals, and even for human races up to recent historical times. While many Asia Minor and Oriental species reach their western limits in the Balkan Peninsula, and others extend beyond, it is certain that there has also been an extension eastwards from the Balkan Peninsula into Asia Minor. It is outside the scope of this work to trace detailed distributions of species in Asia Minor, but a fairly considerable number of plants which have a wide distribution in the Balkan Peninsula, and one which centres there, just extend into Asia Minor, especially into Bithynia. So far as can be ascertained at present this eastward and south-eastward spreading is of much less magnitude than that in the reverse direction. The present distribution of a few species suggests that they originated in the Aegean continental land, or in the islands remaining after this disappeared. It is improbable that there was here an area of species formation and distribution at all comparable either with Greece or with Asia Minor. The geological, palaeontological, and phytogeographical facts available all point to the conclusion that the Aegean land was for the most part low, largely plain, and without high mountain chains or massifs. Thus the species listed above as representative of the special floristic connexion between Crete, Greece, and the Cyclades, on the one hand, and Asia Minor on the other, are almost without exception, coastal, lowland, hill, or montane in their altitudinal zonation, coming in our categories F. 1, 2, 3, or 4. Entirely high mountain plants (F. 5a, 5b, 5c) are very few indeed. It will be shown later that the Alpine species of the Balkan Peninsula (as one part only of the high mountain flora) have extended, almost without exception, from the Alps and Carpathians into the Balkan Peninsula, some few even reaching Olympus in Bithynia, while the main mass of species of the high mountain flora, especially of the south, has developed *in situ*, at least within our area. Thus as based on species, not on genera, it is the coastal to montane species, not the high mountain species which show the floristic connexions between the areas with which we are now concerned. Probably the 'Oriental migration' has been proceeding for long periods, but the changing climatic conditions following the diminution of glaciation in Northern and Central Europe gave an impetus to it. The Aegean land-bridge certainly lasted to post-glacial times. The climate of the eastern

Mediterranean became drier than it was during the Ice Age. Thus physiographic and climatic conditions in immediate post-glacial times favoured eastward extension of Oriental species. Many generic connexions, and even some specific, must, however, date back to Tertiary times. A considerable number of genera common to the Balkan Peninsula and Asia Minor have formed independent centres of species formation and distribution in each of these areas. Good examples are *Dianthus*, *Astragalus*, *Verbascum*, *Onosma*, *Asperula*, and *Anthemis*. While the endemic species of these and other genera may be relatively young the generic distribution must have occurred long ago.

There remains to consider the possibility of hamagenesis, polygenesis, and polytopy. These theories, as applied to the area immediately under consideration, while possible, push back the problem of distribution to an earlier ancestral type and do not solve it. Even if such modes of origin are valid, it is certain that the processes of gradual spread and succeeding interruptions are adequate to explain many existing discontinuities.

Lastly, there are some species common to Asia Minor and the Balkan Peninsula but with peculiarities of known or supposed discontinuous distribution in the latter, and these need individual mention.

Minuartia mesogitana Hand.-Mazz. Greece, Dobruja, Lydia, Pamphylia, Cilicia, Iraq, Transcaspia.

Glaucium grandiflorum Boiss. et Huet. North Macedonia, Dobruja, Asia Minor, Armenia, Iraq, Persia.

Rosa orientalis Dupont. Montenegro, Asia Minor, Armenia to North Persia. I have not seen a specimen from Montenegro and the identification may be incorrect.

Trifolium petrisavii Clem. Thrace, Dalmatia, Asia Minor, Cyprus, Syria.

Vicia sibthorpii Boiss. Crete, Greece, Thessaly, Montenegro, northern Asia Minor.

Oenanthe prolifera L. Crete, Dalmatia, Cilicia, Syria, Palestine.

Torilis homophylla Stapf et Wettst. Montenegro, Hercegovina, Lycia.

Cuscuta globularis Bert. Crete, Greece, Cyclades, Dalmatia, Cilicia, Cyprus, Syria, Palestine.

Majorana onites Benth. Crete, Greece, Cyclades, Dalmatia, Asia Minor, Syria.

All of these species, as at present understood, show various striking kinds of discontinuous distribution. The discontinuity shown by a considerable number of Mediterranean species occurring in Dalmatia

is fully illustrated and discussed elsewhere (p. 348), but it is of interest to note that a number of Asia Minor species are included.

We may now consider the connexions of the Balkan Peninsular flora with those of Cyprus and Syria.

Relationships with Cyprus and Syria. An interesting comparison can be drawn between the flora and vegetation of Crete and that of Cyprus. The two islands are situated in the eastern Mediterranean basin and approximate in size, Crete being 3,330 and Cyprus 3,681 square miles in area. They are practically in the same latitude and are separated by nearly 350 miles of sea. Cyprus is much the nearer to Syria and Asia Minor, and Crete to Greece. Correspondingly the flora of Cyprus is more Oriental and that of Crete more Greek. In both islands the vegetation is of a typical Mediterranean character, the formations being essentially the same as those generally occurring in the countries around the eastern part of the Mediterranean Sea.

The numbers of species known from the two islands are:

	Crete	*Cyprus*
Gymnospermae . . .	7	9
Monocotyledoneae . . .	281	232
Dicotyledoneae . . .	1,145	1,016
Totals	1,433	1,257

Thus in spite of its slightly smaller size 176 more species are known from Crete than from Cyprus. The former has perhaps been a little better explored botanically than the latter, but the difference of 176 species is too great to be thus explained. The probable explanation is to be found in the orography. Crete has much higher mountain groups and peaks than Cyprus. Thus in the west of Crete there are peaks in the Sphakia group 2,300 m. and 2,410 m. in altitude, Ida in Psiloriti attains 2,457 m., and in the eastern Lasiti and Sitia groups the peaks reach 2,155 m. and 1,472 m. respectively, and Kophira in the south 1,143 m. In Cyprus, on the other hand, the highest peaks are: Chionistra 1,953 m., Madhari 1,617 m., Paputsa 1,562 m., Kionia 1,425 m., Irka Steratsa 1,414 m., and Silinidon Muti 1,404 m., all in the Troodos group. Thus the higher altitudinal zones of Cyprus are much less well developed than in Crete, and it is only on Chionistra that high mountain zones occur comparable with those of Crete. Moreover in Crete there are four separate main mountain massifs, three of which reach greater altitudes than the Troodos. In Cyprus all the high peaks are in one group and only a much lower line of hills is separate from this. That Crete has several centres where high mountain species flourish, and some have probably originated, while Cyprus has only one is the most likely cause of the richer flora of Crete.

A comparison of the endemics in the two islands suggests a greater isolation for Crete and parts of Crete than for Cyprus. Thus in the latter 132 species and 2 genera are limited to the island, in the former 69 species and 14 'subspecies' are endemic. Some of the 'subspecies' are probably distinct species and others mere varieties, but even so the number of endemics in Crete is far in excess of those in Cyprus. In both islands endemics occur in all the altitudinal zones, but there is again evidence that it is the greater diversity of physical conditions and the isolation of the mountain groups which account for the greater development of endemics in Crete. Thus in this island a considerable number of endemic species occur in only one mountain group, and sometimes these are represented in one or more of the other groups by distinct though morphologically allied species of the same genus. In Crete also a number of endemic species are limited to altitudes greater than occur in Cyprus.

Crete and Cyprus were probably both separated from their nearlying mainlands in the latter half of the Pliocene Period. There is some geological evidence that Crete had lost its direct connexion with the Peloponnese while it was still joined to the Aegean continent and by this eastwards to Asia Minor and Cyprus. The later dislocations in the Aegean area, however, finally left Crete with Greece as its nearest mainland. Nevertheless there is an interesting phytogeographical connexion between Crete and Cyprus and the following species are common to both islands, but are not known with certainty to occur elsewhere:

Crocus veneris Tappeiner (possibly also in southern Greece), hill and montane zones.
Zelkova abelicea Boiss., montane zone.
Scutellaria hirta S. et S., high mountain zones (5a to 5c).
Galium suberosum S. et S., lowland and hill zones in Cyprus, the Cretan records are somewhat uncertain.
Centaurea cretica Nyman, coastal belt.
Crepis fraasii Sch.-Bip., hill to high mountain zone 5b.

In addition the following species are worthy of mention in the present connexion: *Silene fruticosa* L. is known from Sicily, Greece, and Cyprus; *Fumaria thuretii* Boiss., essentially a Balkan Peninsular species, extends north into the Banat and south-east to Cyprus; *Rhamnus graeca* Boiss. et Reut. is known from Crete, Greece, the Cyclades, and Cyprus; *Galium recurvum* Req. occurs in the Cyclades and Cyprus; *Achillea cretica* L. is known from Crete, Rhodes, and Cyprus, while *Anthemis cretica* Nyman extends from Cyprus west to Crete and Sicily.

It is shown elsewhere (p. 416) that the floristic resemblances between Crete and North Africa (even with Cyrenaica), are not so great as would be expected on geographical grounds alone, nor so great as with Greece and Asia Minor. The main explanation lies in geological history. Cyprus shows even less floristic affinity with North Africa, and the explanation is again that any land connexion between the two areas was broken long before that with Asia Minor and Syria, and that the climate of eastern North Africa has changed (towards greater drought), in late Tertiary or Quaternary times, more than that of Cyprus or Crete. It must also be noted that there are no high mountains in the nearer parts of North Africa so that only the lowland and hill floras of the areas can be compared.

Finally we may note that a limited number of species, so far as is known, miss Asia Minor and Cyprus but are recorded for Syria, Palestine, or farther east, and for the Balkan Peninsula. Some of these may be old species, whose discontinuity of present distribution is a result of the dying out of the species in intermediate localities, while a few certainly suggest polygenesis or polytopy. A selection will suffice to illustrate this small group:

Ononis leiosperma Boiss. 3, 6, 6a. Syria, Persia.
Plantago squarrosa Murr. 6b. Syria, Palestine, and a variety (?) from Egypt.
Valerianella kotschyi Boiss. 7, 8, 8a, 8b. Syria, Iraq.
Campanula athoa Boiss. et Heldr. 2, 3, 4, 4a, 5, 6a, 6b, 8, 8b, 10, 12. Syria.
Anthemis syriaca Bornm. 1. Syria.
Centaurea hyalolepis Boiss. 1, 2. Syria, Palestine, Iraq.

SPECIES ESSENTIALLY CENTRAL EUROPEAN IN THEIR GENERAL DISTRIBUTION (XII.).

These total 920 and represent numerically the most important single category, excepting that of the endemics. When it is remembered that most of the widely distributed species (I.–III.), those with a general European distribution (IV.), the Alpine species (XV.), and the so-called Pannonian species (XIV.), also occur in Central Europe, it will be realized that the floristic linkage between the Balkan Peninsula and continental Europe is very strong. There is no doubt that the absence of continuous barriers, of any description, to north and south distribution is an important factor.

The following families contribute 15 or more species to the total: *Gramineae* 36, *Cyperaceae* 27, *Liliaceae* 16, *Orchidaceae* 23, *Caryophyllaceae* 25, *Ranunculaceae* 40, *Cruciferae* 62, *Rosaceae* 56, *Leguminosae*

43, *Euphorbiaceae* 15, *Umbelliferae* 55, *Borraginaceae* 16, *Labiatae* 31, *Scrophulariaceae* 52, *Rubiaceae* 29, *Campanulaceae* 22, *Compositae* 140.

Palaeontological and geological studies have indicated, without doubt, that the existing flora of Central Europe is more different from the Tertiary flora of the same area, than the Mediterranean flora is from the flora which then occupied the countries of the Mediterranean region, so far as these existed. This is especially true on the negative side. The flora of the lowlands of Central Europe is very much poorer in species than it should be on the basis of existing climatic and edaphic conditions alone. A great many exotic plants flourish exceedingly well and have proved capable of spreading spontaneously after they have been introduced. That the Ice Age had a terribly destructive effect on the Central European flora may be accepted as proved. Moreover the general geography of Europe has not changed in many important respects since the end of the Tertiary epoch. Southern areas unaffected directly by the Ice Age could only contribute species to Central Europe, in post-glacial times, across areas where there were no barriers to northward extension. The importance of the Balkan Peninsula in the history of the Central European flora thus becomes evident. Within the limited scope of this work it will suffice to enumerate the probable temporal connexions between the floras of Central Europe and the Balkan Peninsula. Some questions of very wide import are raised but cannot here be considered in detail.

1. Species whose presence in both Central Europe and the Balkan Peninsula dates from pre-glacial times. A considerable number of hardier species, as *Abies alba* Mill., *Picea abies* Karst., and species of *Carex*, are probably to be included here. It is known that the glaciation of the eastern Alps was less extreme than that of the central, northern, and western Alps, and than that of north Central Europe. There is good evidence that many plants, with their existing centre of dominance or maximum development in the north-western parts of the Balkan Peninsula, spread into pre-war Austro-Hungarian territory beyond our boundaries and there survived the Ice Age in the more protected localities. Thus many Illyrian types (in the sense of Beck) are also east Central European.

2. Species which occur in Central Europe and the Balkan Peninsula but did not reach one area from the other. It has already been mentioned that a considerable number of Balkan Peninsular species, essentially Mediterranean, have an extended distribution northwards in Western Europe. Moreover the gap in the European east-to-west mountain systems in the south of France has enabled species to spread this way into west Central Europe even when they have not extended northwards directly from the Balkan Peninsula.

3. Species which have extended from Central Europe southwards into the Balkan Peninsula. Most of these must have come after the Pontic period and during the Ice Age. The evidence that especially Alpine species spread from the north into the mountains of our area is exceptionally clear, and is dealt with below. It is reasonable to expect that a proportion of montane, hill, and lowland species similarly extended their distribution.

4. Species which have spread northwards into Central Europe from or through the Balkan Peninsula. The clearest evidence of this 'migration' is obtained from a study of the Pannonian species (p. 395). Species capable of greater ecotype differentiation, of more rapid dispersal, and of more certain ecesis, extending northwards have passed beyond the area of the Pannonian flora into Central Europe proper.

5. Species owing their extension to man's activities. This subject has been considered in Chapter X, and it will suffice to say here that many weeds, ruderals, and aliens of Central Europe occur in natural habitats in the Balkan Peninsula. Species of *Polygonaceae*, *Chenopodiaceae*, *Papaveraceae*, *Cruciferae*, and *Compositae* furnish examples.

It has been shown above that an extension or migration westwards and northwards from Asia Minor, the eastern Mediterranean Basin, and the Orient is clearly indicated by a study of the Balkan Peninsular flora. That many species coming from the east and south-east should spread beyond our limits into Central Europe would be a natural expectation. That a considerable number should produce species different from the original eastern or south-eastern ancestral type during the course of the extension or migration is also most likely. Hence many species common to the Balkan Peninsula and to Central Europe do not occur to the south-east or east of our area but are there represented by vicarious or pseudovicarious species of the same genus. In this as in so many other respects the Balkan Peninsula is a link between Europe and Western Asia. It is of interest to note that somewhat analogous ethnological conclusions have been reached by Myres and others, though with important differences in detail.[1]

CONNEXIONS TO THE NORTH WITH THE OLD AUSTRO-HUNGARIAN TERRITORIES AND WITH ROUMANIA, TO THE NORTH-EAST WITH SOUTH RUSSIA, AND TO THE EAST WITH THE COUNTRIES BORDERING ON THE BLACK SEA.

The distributions analysed in this section comprise my divisions Dacian (XIII.), Pannonian (XIV.), and Pontic (XIV.a). It must be clearly understood that I use these terms in a purely geographical

[1] See Myres, *The Dawn of History*, 40–1 (London, 1911), and in *Scottish Geogr. Mag.* xl. 129 seq. (1924).

sense without any specialized ecological meaning, and with no reference to time of distribution or genesis. 'Pannonian' species as listed in my Balkan Peninsular work are those common to the Balkan Peninsula and the area of the old Austro-Hungarian empire to the north (excluding the eastern Alps), or part or parts of it. 'Dacian' species similarly are those common to the Balkan Peninsula and the area from Roumania to the Crimea inclusive, or part or parts of it. 'Pontic' species are those which extend around the Black Sea, or parts of it, from Asia Minor to the Balkan Peninsula; they may extend west and then north-west into Thrace or South Bulgaria and sometimes beyond, or they may extend north and then west over the Dacian area and into the Balkan Peninsula from the north-east.

It is necessary to bear in mind (1) that there is no existing continuous east and west barrier between the Balkan Peninsula and the north; (2) that the Carpathians are only separated from the Balkan mountains (especially from those of the north-west offshoots of the Stara Planina) by the break-through of the Danube at the Iron Gates and Kasan Pass; (3) that parts of the Carpathians have been land since early Tertiary times; (4) that the Hungarian and Roumanian plains were covered with the waters of the Sarmatic and Pontic seas and lakes till relatively recent geological times; (5) that the Bosporus is no wider than a broad river; (6) that the Aegean Sea is geologically of recent formation. It follows that migration between the Carpathians and the Stara Planina and thence to other parts of our area has been possible through long eras; that migration on a wide front between the lowlands of the Balkan Peninsula and those to the north has been possible for land plants only since the end of the Tertiary period and must for the most part have been in one direction—northwards—as the Sarmatic and Pontic waters dried up; that migration along the northern (Pontic) parts of Asia Minor into the Balkan Peninsula is geographically feasible, and has been even more so in past geological periods.

Dacian connexions. The total number of species having the distribution XIII., solely or partly, is 178. It will suffice to name a selection of these, giving their general and Balkan Peninsular distributions, the latter in brackets with the figure symbols as used throughout this work. Species essentially XIII. but extending into Hungary, or beyond, from the Balkan Peninsula are dealt with separately.

Koeleria degenii Domin. S. Russia, Bessarabia. (8, 9).

Stipa lessingiana Trin. et Rupr. S. Russia to Cent. Transylvania. (9).

Scirpus hamulosus Steven. S. Russia. (8a, 9).

Arenaria rigida Bieb. Crimea, S. Russia, Roum. (8, 9).

Dianthus campestris Bieb. Cauc. to S. Russia. (8, 8a).

D. capitatus Balb. Cauc. to S. Russia. (6, 8, 8b, 9, 10).

D. kladovanus Degen. Roum. (10).
D. pseudarmeria Bieb. Cauc., Crimea, S. Russia, Roum. (6a, 7, 8, 8a, 9).
Gypsophila glomerata Pall. Cauc., Crimea, S. Russia, Roum. (8, 8a, 9).
Silene wolgensis Otth. Cauc. to S. Russia. (8, 9).
Potentilla geoides Bieb. Cauc., Crimea. (8b).
P. patula W. et K. S. Russia. (8, 8b, 10, 12).
Astragalus albicaulis DC. Cauc., S. Russia. (6, 8, 9).
A. arnacantha Bieb. Crimea, Cauc. (8a).
A. diffusus Willd. S. Russia, Crimea, Cauc. (9).
A. pubiflorus DC. Centr. and S. Russia, Crimea. (7, 8, 9).
Genista albida Willd. S. Russia, Cauc. (9).
G. tetragona Bess. S. Russia. (8b).
Hedysarum tauricum Pall. Crimea. (8).
H. grandiflorum Pall. S. Russia. (9).
Medicago rupestris Bieb. Crimea. (8a, 8b).
Onobrychis gracilis Besser. S. Russia, Crimea, Roum. (6a, 7, 8, 8a, 8b, 9, 11).
Trigonella spicata S. et S. Crimea, Cauc. (2, 2a, 3b, 8b).
Erodium serotinum Steven. Roum., Podolia, S. Russia to Cauc. (9).
Malabaila graveolens Hoffm. Roum., S. Russia, Crimea, Cauc. (7, 8, 9).
Seseli campestre Besser. Roum., S. Russia. (8, 9).
Symphytum tauricum Willd. Crimea, Cauc. (8, 8a, 9).
Satureia caerulea Janka. Roum. (8, 8a, 8b, 9).
Stachys angustifolia Bieb. S. Russia, Crimea, Roum. (3, 3a, 6, 6a, 7, 8, 8a, 8b, 9).
S. arenariaeformis Rouy. Roum. (8).
Asperula tyraica Besser. Moldavia, Galicia, S. Russia. (8, 8a, 9).
Carduus uncinatus Bieb. S. Russia, Crimea, Cauc., Turcomania. (8, 8a).
Centaurea besseriana DC. Podolia. (8, 9).
C. marschalliana Spreng. Centr. and S. Russia, Urals. (8, 9).
C. orientalis L. S. Russia, Cauc. (6, 8, 8a, 8b, 9, 10).
C. salina L. S. Russia, Cauc. (9).
C. sterilis Steven. Crimea. (8, 10).
C. tenuiflora DC. Crimea. (8, 9).
Chondrilla graminea Bieb. S. Russia. (8).
Jurinea stoechadifolia DC. S. Russia, Crimea. (9).

The above list is by no means exhaustive, and above all it does not include species with a wide distribution which have entered the Balkan Peninsula via southern Russia and Roumania. A considerable

number of Central Asiatic species have entered this way and are of necessity classed as 'wides' (III.). Good examples are many species of *Chenopodiaceae*, and the matter is discussed in Chapter VIII (p. 123). That most of these occur in the Dobruja and some extend into North Bulgaria or farther is in agreement with the distribution of the species listed above, and with the general geographical position. There are very few species whose present distribution would appear to indicate any direct floristic connexion between the Stara Planina and the mountains of the Crimea or with the respective adjacent lowlands. Indeed, the number is so small, relative to the size and distinctness of the floras involved, that it has no positive significance, and it may well be that the species also occur in South Russia and the Dobruja but have not been recorded, or that I have overlooked the records in the scattered literature. Nikolsky [1] has postulated, on zoological grounds, a *via balcanica*, from Cape Sarych, in the Crimea, to Cape Emine, in Bulgaria. This is supposed to have been a land connexion linking the Yaila mountains with the Stara Planina, and to have lasted till the end of the Tertiary epoch. I find practically no floristic evidence in favour of this view. The distributional facts combined with a knowledge of the geological history point to an important migratory movement around the northern parts of the Black Sea into the north-east of the Balkan Peninsula, and to an equivalent but less important reverse migration from the Balkan Peninsula into southern Russia and Roumania. The species involved are nearly all herbaceous or suffruticose and many are inhabitants of grasslands or of coastal communities.

Pannonian connexions. We will first consider a list of species which are essentially Balkan Peninsular but which have spread northwards into old Austro-Hungarian territories. The definite Carpathian and Alpine connexions are excluded in the list given immediately below, as are also those species of wider distribution which may have used the Balkan Peninsula as a route to Hungary. It is of interest to note that many of the species were first described from Hungary (in the pre-war sense) and some even bear trivial geographical names indicating this.

Alopecurus laguriformis Schur. This species is doubtfully distinct from the Central Asian *A. brachystachys* Bieb. A number of microspecies of the *Bromus erectus* group certainly extend northwards from the Peninsula into Hungary and include *B. pannonicus* Kumm. et Sendtn., *B. stenophyllus* Link, and *B. transsilvanicus* Hack.

Avenastrum blavii Beck is recorded from the Tyrol.

Heleocharis carniolicus Koch from the eastern Balkan Peninsula to Carinthia, Carniola, Styria, North Italy, and Roumania.

Colchicum arenarium W. et K.

[1] *Mém. de l'Acad. de Petersb.* lxviii, Suppl. no. 4 (1891).

Tulipa hungarica Borb.
Lilium carniolicum Bernh., including several varieties.
Iris variegata L.
Comandra elegans Reichb. fil. An interesting morphologically isolated type in Europe, extending from the Balkan Peninsula into southern Hungary, the Banat, Transylvania, Roumania, and south-east into Bithynia.
Cerastium banaticum Heuff.
Dianthus armeriastrum Wolffn., *D. compactus* Kit. (also from Cent. Italy ?), *D. diutinus* Kit., *D. giganteus* Urv., *D. kitaibelii* Janka, *D. pontederae* Kern., *D. puberulus* Kern.
Melandrium nemorale A. Br.
Minuartia graminifolia Jávorka.
Moehringia pendula W. et K.
Scleranthus neglectus Roch.
Silene dichotoma Ehrh., *S. flavescens* W. et K., *S. lerchenfeldiana* Baumg., *S. trinervia* Seb. et Maur.
Viscaria atropurpurea Griseb.
Delphinium fissum W. et K.
Helleborus atrorubens W. et K., *H. dumetorum* W. et K., *H. multifidus* Vis., *H. odorus* W. et K.
Fumaria thuretii Boiss.
Alyssum saxatile L.
Arabis procurrens W. et K., *A. scopoliana* Boiss. just reaches from our area to Nanos.
Dentaria trifolia W. et K.
Hesperis silvestris Crantz.
Lunaria pachyrrhiza Borb.
Nasturtium lippizense DC. north to Carniola and Carinthia.
N. proliferum Heuff.
Peltaria alliacea Jacq.
Thlaspi avalum Panč., *T. goesiingense* Hal., *T. kovatsii* Heuff., *T. praecox* Wulf north to Carniola and S. Tyrol and also into Italy.
Crataegus nigra W. et K.
Potentilla australis Kras. into Carniola, *P. ternata* C. Koch to Hungary and E. Alps, and also Bithynia.
Coronilla elegans Panč.
Cytisus ciliatus Wahlenb., *C. diffusus* Vis. north to Hungary and Styria, *C. procumbens* Spreng., *C. purpureus* Scop.
Genista holopetala Fleischm. north to Carniola, *G. sericea* Wolf north to S. Tyrol, *G. silvestris* Scop. north to E. Alps, *G. triangularis* Kit., north to Carniola.
Medicago carstiensis Wulf north to S. Tyrol, *M. prostrata* Jacq.

Onobrychis alba Desv. north to Banat and Roumania.
Orobus alpestris W. et K.
Trifolium angulatum W. et K.
Vicia oroboides Wulf north to Lower Austria and Roumania, *V. sparsiflora* Ten.
Erodium neilreichii Janka.
Geranium caeruleatum Schur.
Linum hologynum Reichb., *L. nervosum* W. et K.
Ruta patavina L. north to Carniola and N. Italy.
Polygala carniolica Kern. north to Carniola, *P. croatica* Chod. north to Carniola.
Euphorbia polychroma Kern. north to Austria, *E. salicifolia* Host north to Austria, *E. veneta* Willd. north to Friaul.
Rhamnus rupestris Scop., *R. tinctoria* W. et K.
Tilia tomentosa Moench.
Kitaibelia vitifolia Willd.
Hypericum alpinum W. et K.
Daphne blagayana Freyer.
Anthriscus fumarioides Spreng. north to Carniola.
Bupleurum aristatum Barth. north to Carniola, S. Tyrol, and N. Italy.
Ferula heuffelii Griseb. north to Banat and Wallachia.
Peucedanum longifolium W. et K.
Seseli gracile W. et K., *S. leucospermum* W. et K., *S. medium* Hand.-Mazz. north to Venetia and Hungary, and *S. rigidum* W. et K.
Syringa vulgaris L.
Gentiana lutea L. subsp. *symphyandra* Murb. north to Venetia, *G. lutescens* Vel., *G. tergestina* Beck north to Carinthia.
Anchusa barrelieri Vitm. north to Hungary, and also into Italy and Asia Minor.
Cynoglossum hungaricum Simonk.
Onosma echioides L. sensu Jávorka, *O. viride* Jávorka, *O. visianii* Clem.
Pulmonaria rubra Schott.
Rindera umbellata Schult.
Symphytum ottomanum Friv.
Lamium inflatum Heuff.
Micromeria pulegium Benth.
Salvia amplexicaulis Reichb. (*S. villicaulis* Borb.).
Satureia kitaibelii Wrzb., *S. subspicata* Barth. north to Carniola.
Thymus acicularis W. et K.
Alectorolophus rumelicus Borb. north to Thuringia and Hungary.
Digitalis laevigata W. et. K., *D. lanata* Ehrh.

Verbascum austriacum Schott north to Austria, *V. banaticum* Roch.
Veronica baumgartenii R. et S., *V. crassifolia* Wrzb.
Acanthus longifolius Host.
Asperula capitata Kit.
Galium flavescens Borb., *G. pseudoaristatum* Schur.
Knautia macedonica Griseb. north to Carinthia and Roumania, *K. sarajevensis* Szabo north to Carinthia.
Scabiosa hladnikiana Host, *S. scopolii* Link, *S. silenifolia* W. et K. north to Carinthia and also Italy.
Campanula abietina Griseb. et Sch., *C. crassipes* Heuff., *C. grossekii* Heuff., *C. kladniana* Witasek, *C. lingulata* W. et K., *C. macrostachya* Willd., *C. racemosa* Witasek north to Lower Austria.
Achillea compacta Willd., *A. lingulata* W. et K.
Anthemis macrantha Heuff.
Artemisia petrosa Janchen, also in Italy.
Carduus glaucus Baumg.
Carlina brevibracteata Simonk.
Centaurea cristata Bartl. north to Carniola, *C. haynaldii* Borb. north to Carniola, *C. micrantha* Gmel., *C. mollis* W. et K., *C. spinulosa* Roch, *C. stenolepis* Kern., *C. triniaefolia* Heuff.
Chrysanthemum uliginosum Pers.
Cirsium decussatum Janka, *C. grecescuii* Rouy, *C. montanum* Spr., also in Italy, *C. pauciflorum* Spreng.
Crepis chondrilloides Jacq. north to Carinthia, *C. viscidula* Froel.
Doronicum longifolium Griseb. et Schenk.
Echinops commutatus Juratzka.
Hieracium rotundatum Kit.
Jurinea macrocalathia C. Koch.
Mulgedium sonchifolium Vis. et Panč.
Picris sonchoides Vest.

The above list, although by no means exhaustive, is sufficient to emphasize the fact that not merely are the floras of the Balkan Peninsula and the old Austro-Hungarian territories to the north floristically closely related, but that the latter owe much of their flora to migration from the former. The stream of migrants does not consist, in the main, of Balkan Peninsular species but of species which have used this area as a route by which they have reached the districts to the north. There follows here a list of species which are essentially Dacian or Pontic types which have spread north-west as far as Hungary or even farther. It is, of course, possible that some have really originated in the Balkan Peninsula and spread north-east as well as north and north-west, but the evidence is against this for the majority.

Some have no doubt entered the Balkan Peninsula and Hungary independently, for example, certain species of *Corispermum*, but many, and probably most, have invaded Hungary from the Balkan Peninsula.

Melica picta C. Koch.
Oryzopsis virescens Beck.
Pholiurus pannonicus Trin.
Juncellus pannonicus C. B. Cl.
Fritillaria tenella Bieb.
Muscari tenuiflorum Tausch.
Ornithogalum refractum Kit.
Iris aphylla L.
Thesium dollineri Murb.
Beta trigyna W. et K.
Corispermum canescens Kit., *C. filifolium* C. A. Mey.
Minuartia glomerata Degen, *M. hirsuta* Hand.-Mazz.
Paronychia cephalotes Besser.
Silene longiflora Ehrh.
Delphinium paniculatum Host.
Paeonia tenuifolia L.
Ranunculus pedatus W. et K.
Alyssum tortuosum W. et K.
Bunias orientalis L.
Isatis praecox Kit.
Reseda odorata Reichb.
Potentilla patula W. et K., *P. taurica* Willd.
Rosa ferox Bieb.
Waldsteinia geoides Willd.
Astragalus dasyanthus Pall. *A. varius* Gmel.
Orobus pallescens Bieb.
Trifolium pannonicum Bieb.
Trigonella caerulea Ser., *T. procumbens* Reichb.
Linum hirsutum L.
Euphorbia agraria Bieb. *E. glareosa* Bieb.
Viola dacica Borb.
Bupleurum affine Sadl., *B. commutatum* Boiss. et Bal.
Ferulago silvatica Reichb.
Oenanthe banatica Heuff.
Peucedanum arenarium W. et K.
Torilis microcarpa Besser.
Swertia punctata Baumg.
Anchusa procera Besser.
Echium rubrum Jacq.
Ajuga laxmannii Benth.
Marrubium praecox Janka.
Salvia nutans L.
Verbascum speciosum Schrad.
Veronica orchidea Crantz.
Jasione jankae Neilr.
Centaurea arenaria Bieb.
Chrysanthemum macrophyllum W. et K.
Crepis rigida W. et K.
Doronicum orientale Hoffm.
Echinops banaticus Roch.

Some plants of still wider general distribution have also probably reached Hungary via the Balkan Peninsula, or for a few of them the invasions may have been independent. A selection of such is given below with the Roman figures for their general distribution.

Delphinium orientale Gay V.
Euclidium syriacum R. Br. XI. XVIII.
Cytisus elongatus W. et K. VIII.
Vicia truncatula Fisch. XI.
Paliurus spina-Christi Mill. V.
Ammania verticillata Lam. XI. XVIII.
Danaa cornubiense Burn. VI. and W. Europe.
Oenanthe media Griseb. X.
O. silaifolia Bieb. VIII. XVIII.

Vinca herbacea W. et K. X. XIII. XVIII.
Linaria dalmatica Mill. XI. XIV.a XVIII.
Inula bifrons L. VIII.
Orthantha lutea Kern. VI. XIII. XIV.a XVIII.
Galium divaricatum Lam. VI.
Centaurea diffusa Lam. X. XIII. XIV. XVIII.

For most of the plants hitherto listed as examples of the floristic connexions between the Balkan Peninsula and the old Austro-Hungarian territories to the north we have, for geological reasons, been forced to postulate a northern migratory movement, in the sense of a northern extension of their distribution since the lowlands and hill zone became dry land. A number of species, mostly high mountain plants, are common to the Carpathians and to the Balkan Peninsula but do not extend beyond or scarcely beyond these areas. In listing these it will be useful to give the figures indicating their Balkan Peninsular distribution.

Crocus heuffelianus Herb. (5, 6a, 8, 10, 11, 12, 14, 15).
Gymnadenia frivaldii Hampe. (6, 8, 8b, 11).
Aconitum toxicum Reichb. (12).
Dentaria glandulosa W. et K. (10, 14, 15).
Saxifraga carpatica Reichb. (8b).
S. corymbosa Boiss. sensu Engl. et Irmsch., also from Caria. (8b).
S. marginata Sternb. sensu Engl. et Irmsch., also from Italy. (2, 3, 4, 5, 6, 8, 10, 11, 12, 13, 14, 15).
Potentilla haynaldiana Janka. (6a, 8, 8b).
Cytisus leiocarpus Kern. (8, 12).
Hypericum transsilvanicum Čelak. (8).
H. umbellatum Kern. (8, 8a, 10).
Laserpitium alpinum W. et K. (8, 10, 15).
Bruckenthalia spiculifolia Reichb., also from Asia Minor. (6, 6a, 8, 8b, 10).
Rhododendron kotschyi Simonk. (8, 8b).
Soldanella hungarica Simonk. (6, 6a, 8, 10, 15).
Gentiana bulgarica Vel. (5, 6, 8, 8b, 10).
Calamintha patavina Host. (3, 3b, 4, 5, 6, 6a, 6b, 7, 8, 8a, 9, 10, 11, 12, 13, 14).
Scopolia carniolica Jacq., also in N. Croatia. (10, 15).
Alectorolophus alpinus Sterneck., also from the Caucasus. (8, 8a, 11, 13, 15).
Melampyrum bihariense Kern. (10, 12, 13).
Pedicularis limnogena Kern. (5, 6, 6a).
Plantago gentianoides S. et S., also from Asia Minor. (5, 6, 8b).
Symphyandra wanneri Heuff. (8, 8b, 10).

Adenostyles kerneri Simonk. (5, 12, 13).
Centaurea atropurpurea W. et K. (5, 8, 9, 10, 11, 15).
Hypochaeris carpatica Pax (5, 11).
Senecio carpaticus Herb. (5, 6, 6a, 8, 8b, 10).

A second list also probably shows the close floristic connexions between the Carpathians and the Balkan Peninsula, but the species included in it either considerably extend their distribution in other directions or the evidence accumulated is not so clear.

Avenastrum planiculme Jessen (6, 8, 8b, 10, 13).
Melandryum nemorale A. Br. (6a, 8b, 10, 10a, 11, 12, 13, 15, 16).
Moehringia pendula Fenzl (6, 6a, 8, 8b, 10, 15).
Scleranthus neglectus Roch. (2, 2a, 3, 3b, 4, 5, 6, 6a, 7a, 8, 8b, 10, 11, 12).
Silene lerchenfeldiana Baumg. (6, 6a, 8, 8b, 10).
Helleborus odorus W. et K. (5, 6, 8, 8a, 9, 10, 10a, 11, 12, 13, 15, 16).
Ranunculus crenatus W. et K. (5, 6, 8b, 11).
Arabis procurrens W. et K. (6, 6a, 8, 8b, 10, 12, 15).
Thlaspi kovatsii Heuff. (2, 3b, 4, 5, 6, 8, 8b, 10, 12).
Syringa vulgaris L. (6, 8, 8a, 8b, 9, 10, 11, 12, 13, 14, 15, 16).
Pulmonaria rubra Schott. (5, 6, 6a, 8, 8b, 10).
Micromeria pulegium Benth. (10, 15).
Pedicularis campestris Griseb. (8, 10).
Veronica baumgartenii R. et S. (8, 10).
Campanula grossekii Heuff. (8, 8a, 10).
Achillea lingulata W. et K. (5, 6, 8, 8b, 10, 11, 12, 13).
Anthemis carpatica W. et K. (5, 6, 6a, 8, 8b, 10, 11).
Centaurea kotschyana Heuff. (8, 8b, 10, 11, 12, 13).
Crepis viscidula Froel. (5, 6, 8, 8b, 10, 11, 12, 13).
Erigeron atticus Vill. (8b, 11, 12, 13, 14).

The connexion between the Carpathians and the Balkan Peninsula is evidently one of considerable importance. It is probable that the connexion is of mixed origins. There has doubtless been extension of specific distribution in both directions resulting in a kind of interchange of species, but the possibility of hamagenetic or polytopic origin for some of the species is not to be ignored. It is obvious from the above lists that two connexions in different geographical directions may be traced: the one leading from the Carpathians to the Stara Planina and the Rodope massif, the other, of less importance, leading to the mountains of Bosnia, Montenegro, and Albania. There is little doubt that in addition to the species listed there are many other high mountain plants which are really connexions between the floras of the Carpathians and the Bulgarian mountains, but since they have

a wide distribution also in the Alps, often in other European mountains, and even in the sub-Arctic and Arctic, they are not included here. It is, however, important to call attention to Jordanoff's researches on the flora of the western Stara Planina. In a recent paper [1] he shows that the oreophytic vegetation is most closely related to that of the Carpathians, 86 per cent. of all the species occurring also in those mountains. Correspondingly the Vitoša has 82 per cent., the Rila 84 per cent., Pirin 43 per cent., and the central Stara Planina 71 per cent. of oreophytic species in common with the Carpathians. There is thus a decrease from north to south via the western Stara Planina and Rila to Pirin, but there is a decided break between the western and central Stara Planina, and the Vitoša lacks a number of species present in the adjacent but more southern Rila. The latter fact may find an explanation in the geological history of the Vitoša if Penck's conclusions are correct (see p. 37), though it is also to be noted that some species common to the Rila and the Carpathians miss the Stara Planina even as they do the Vitoša. The second connexion, leading from the Carpathians to the western mountains of the Balkan Peninsula, is exemplified by *Aconitum toxicum* Reichb., *Dentaria glandulosa* W. et K., *Scopolia carniolica* Jacq., *Melampyrum bihariense* Kern., *Pedicularis limnogena* Kern., *Adenostyles kerneri* Simonk., and *Hypochaeris carpatica* Pax. A relatively large number of species have extended in both the above directions or have such a distribution in the Balkan Peninsula that it is not at present possible to trace the directions of their extensions.

Pontic connexions. We have now to discuss the connexions between the floras of the Balkan Peninsula and the countries around the Black Sea, excluding those species which are limited to the northern parts of the Pontic area. In giving a selected list it will be useful to have the general and Balkan Peninsular distribution for each species. The list given above of Pontic (and Dacian) species spreading into the Balkan Peninsula and northwards may also be consulted.

Elymus sabulosus Bieb. South Russia to Cauc. and Caspian Sea (6, 7, 8, 8a, 9).
Asphodeline taurica Pall. Crimea, Asia Minor. (6a, 8, 8a, 8b).
Galanthus plicatus Bieb. Crimea, Bithynia. (7, 9).
Fagus orientalis Lipsky. Cauc., N. Asia Minor. (8, 8a, 8b, 9).
Ranunculus oxyspermus Bieb. Roum., S. Russia, Crimea, Cauc., and east to N. Persia. (8, 8a, 8b, 9).
Alyssum minutum Schlecht. Asia Minor, Cauc., S. Russia. (1, 2, 3, 6, 6a, 7, 8, 8a, 9).

[1] *God. na Sofijskii Universit.* xx. 1, 1924.

Reseda inodora Reichb. has a wide distribution from Asia Minor, Cauc., Crimea, S. Russia, Roum., to Hungary. (6, 6a, 8, 8a, 8b, 9, 10).

Potentilla taurica Willd. S. Russia, Cauc., Asia Minor. (6, 8, 8a, 8b, 9, 10, 11, 14).

Pyrus elaeagnifolia Pall. Asia Minor, Armenia, Cauc. (9).

Rosa ferox Bieb. Crimea, Cauc., Asia Minor. (6a, 8, 16).

Waldsteinia geoides Willd. Galicia, Crimea, Cauc. (8, 10, 10a).

Astragalus glycyphylloides DC. Crimea, Asia Minor. (2, 3a, 6, 8, 10, 11, 12).

A. ponticus Pall. S. Russia, Crimea, Armenia, Asia Minor. (6a, 7, 8, 9).

Dorycnium latifolium Willd. Crimea, Cauc., Asia Minor. (2, 3, 6a, 6b, 7, 8).

Orobus aureus Steven. Crimea, Cauc., Asia Minor. (8, 8a, 9).

O. pallescens Bieb. Cauc., Armenia, Asia Minor. (8, 9, 10).

Geranium striatum L. Cauc., N. Asia Minor, S. Italy. (2, 3, 3b, 5, 6, 6b).

G. subcaulescens L'Hér. Armenia, N. Asia Minor. (2, 3, 3b, 4, 5, 6, 11, 14).

Linum hirsutum L. Orient, S. Russia, Poland, Austria, Moravia. (5, 6, 6a, 7, 8, 8a, 8b, 9, 10, 14, 15).

Euphorbia petrophylla C. A. Mey. Crimea, Cauc., N.-E. Asia Minor. (9).

Althaea armeniaca Ten. Cappadocia, Armenia, Cauc., and ? N. Syria. (7).

Hypericum calycinum L. N. Asia Minor, Cauc. (7).

Viola pontica W. Becker. S. Russia, Cauc., Asia Minor to Transcaspia, Turkestan, and Kashmir. (6, 8, 10, 12).

Daphne pontica L. Cauc., Asia Minor. (7, 8b).

Pastinaca teretiuscula Boiss. Cauc., Asia Minor, ? Lebanon. (8, 9).

Peucedanum obtusifolium S. et S. N. Asia Minor. (2, 7).

P. ruthenicum Bieb. S. Russia, Crimea, Cauc., N. Asia Minor. (8, 9, 11, 13).

Myosotis litoralis Steven. Crimea, Bithynia. (2, 7).

Trachystemon orientale Don. Cauc., Asia Minor. (7, 8a).

Stachys lanata Jacq. Crimea, Cauc., N. Asia Minor, and east to Persia. (7, 7a).

S. sideritoides Koch. Cauc., Armenia. (5, 6a, 8, 8b, 9).

Scabiosa bicolor Boiss. Armenia. (8).

S. micrantha Desf. S. Russia, Crimea, Cauc., Armenia. (6, 7, 8, 8a, 8b, 10).

S. rotata Bieb. Asia Minor, Armenia, and ? east to Persia. (6, 8a, 8b).

Campanula hemschinica C. Koch. S. Russia, Cauc., N.-E. Asia Minor. (8, 8b, 10).

Jasione supina Sieber. N. Asia Minor. (4, 5, 6, 8, 8b, 10, 11, 12).

Anthemis rigescens Willd. Cauc., N.-E. Asia Minor. (5, 6b, 7, 10, 11, 12, 13).

Artemisia annua L. Cauc., N.-E. Asia Minor, and to the Caspian Sea. (6a, 7, 8, 8a, 9, 10, 11, 12).

Chrysanthemum millefoliatum L. Crimea, Cauc., N.-E. Asia Minor. (8, 9).

Lapsana intermedia Bieb. Crimea, Cauc., Armenia, N. Asia Minor. (6a, 6b, 7).

Senecio othonnae Bieb. Cauc., Armenia, and to N. Persia. (5, 6b, 8, 8a, 10, 11).

There are a few miscellaneous observations worthy of record. The absence of *Orchidaceae* with distribution XIII., XIV., or XIV.a is remarkable. *Anchusa osmanica* Vel. has the Balkan Peninsular distribution 6a, 7, 8, 8a, 8b, 11, but extends north to Bessarabia and Silesia. *Thymus zygioides* Griseb. extends from the Balkan Peninsula (6, 6a, 7, 8, 8a, 8b, 9) north into Roumania and south into Asia Minor.

The mountain connexions between the Carpathians and the Balkan Peninsula have been dealt with above, but it is necessary to mention the low mountains in the northern part of the Dobruja. These have no orographical or geological connexion with either the Stara Planina or the Carpathians. Correspondingly they have had practically no influence upon the mountain flora of the Balkan Peninsula as a whole. Their importance lies in their great age, their remaining above the waters of the Sarmatic and Pontic seas and lakes, and their probable connexion in past geological ages with the mountains of the Crimea and Caucasus. It is safe to assume that they formed a refuge for relatively old types of plants, and to this fact is due the richness of the Dobruja in Tertiary relicts. On the other hand there is little evidence that a more direct connexion, in past times, with either the Crimea or the Caucasus has had any appreciable influence upon the existing specific constitution of the flora of the Balkan Peninsula. The evidence, indeed, points to the existing land connexion to the north and the circuitous routes around the Black Sea as being sufficient to explain the present distribution of the vast majority of the species. This applies equally to the Stara Planina in relation to the Crimea and Caucasus.

A consideration of the steppe flora of the Balkan Peninsula and its extension into Hungary and Roumania has now to be presented. My researches have strongly pointed to the view that though there is a steppe vegetation with ecologically well-marked characteristics

there is not, so far as the Balkan Peninsula is concerned, a steppe flora. I am even inclined to extend this statement to Europe as a whole. The meaning is that the species composing the steppe vegetation have with few exceptions a distribution, and often a wide one, outside the steppes in other ecological communities. This is especially true of species which largely dominate the steppes of North Bulgaria, the Dobruja, the Hungarian plains, and South Russia. The fact coincides with my view that the steppe vegetation has originated by extension of the distribution of species from various communities and from various directions, but especially from the south. Professor Stoyanoff [1] has clearly shown that a considerable part of the more widely spread steppe plants of Bulgaria have distributional or taxonomic connexions with the Mediterranean flora.

The Hungarian and Roumanian plains are geologically very young and their terrestrial plant covering can only have spread over them since Pontic times. A good proportion of their flora came from or via the Balkan Peninsula, of which large areas remained above the late Tertiary seas and lakes. A considerable number of species crossed the Danube or the Save northwards or westwards (from the Dobruja), but others have hitherto found the river and marsh barrier impassable. The following species occur in the Dobrujan steppes but apparently not in those of the rest of Roumania: *Eurotia ceratoides* C. A. Mey., *Dianthus pallens* S. et S., *Gypsophila glomerata* Pall., *Leontice altaica* Pall., *Crambe tataria* Sebéok, *Astragalus asper* Wulf, *Onobrychis gracilis* Besser, *Astrodaucus bessarabicus* Drude, *Bupleurum apiculatum* Friv., *Ferulago meoides* Boiss., *Seseli campestre* Besser, *Goniolimon besserianum* Nyman, *Limonium latifolium* O. Kuntze, *Rochelia disperma* Stapf, *Tournefortia sibirica* L., *Satureia caerulea* Janka, *Stachys angustifolia* Bieb., *S. sideritoides* Koch, *Phlomis pungens* Willd., *Artemisia arenaria* DC., *Centaurea salonitana* Vis., *C. tenuiflora* DC., *Jurinea stoechadifolia* DC., *Tragopogon floccosus* W. et K. Certain plants occur in the Dobruja and also in western Roumania but are absent in the intermediate parts. Examples are: *Marrubium peregrinum* L., *Scabiosa ucranica* L., *Achillea compacta* Willd., and *Crupina vulgaris* Cass. These have a wide distribution within the Balkan Peninsula and may well have spread north in and from more than one district. That a considerable number of species have entered the Balkan Peninsula from the north-east is certain, but it does not follow that these have originated in the contiguous steppe districts. It is not desirable here to enter into details, but the evidence clearly points to a large number having entered via South Russia from areas farther east and south-east. It is also clear that the Balkan Peninsula has contributed

[1] *Journ. Ecol.* xiv. 138 seq. (1926).

to the steppe vegetation from its own original flora and by acting as one route for Mediterranean species. Some of these latter have extended far into the steppe districts but the following reach their northern limits, so far as Roumania is concerned, in the Dobruja: *Vallisneria spiralis* L., *Polypogon monspeliensis* Desf., *Ficus carica* L., *Medicago marina* L., *Geranium asphodeloides* Burm., *Peganum harmala* L., *Paliurus spina-Christi* Mill., *Frankenia pulverulenta* L., *Pimpinella tragium* Vill., *Periploca graeca* L., *Stachys maritima* L., *Ecballium elaterium* Rich., *Micropus erectus* L., and *Scolymus hispanicus* L. A number of the above species are Mediterranean only relatively to the Balkan Peninsula, having a wider absolute distribution. In addition the following species of the North Bulgarian flora have not spread over the Danube into pre-war Roumania. *Corydalis marschalliana* Pers., *Cynanchum acutum* L., *Nonnea atra* Griseb., and *Jasione heldreichii* Boiss. et Orph.

The destruction of forests by man has led to the extended distribution of species often designated 'steppe plants'. This is certainly true for the Balkan Peninsula and probably also for contiguous countries. Stoyanoff has separated from such a secondary steppe vegetation 'a primeval xerothermic element' in Bulgaria. While this latter consists of species which physiognomically might well enter into extensive steppe vegetation it is questionable whether the term 'steppe' should be applied to it at all. Rather it appears to consist of species which have failed to enter the existing steppe vegetation; and indeed many of them seem on the down-grade towards extinction.

Hayek [1] has discussed the use of the terms 'Pontic' and 'Pannonian' and brings forward good evidence to show that the 'West Pontic Forest-flora' in the sense of Drude has been in south-east Europe since Tertiary times, although it retreated with the oncoming of the Ice Age and spread again after the retreat of the glaciers. On the other hand the steppe-element migrated much later and invaded the lowlands and even the wooded areas. In general my conclusions agree with those of Stoyanoff and Hayek although arrived at independently and along quite different lines of work.

CONNEXIONS WITH THE FLORA OF THE ALPS (XV.).

The phrase 'Alpine Flora' has been used with two meanings, to designate either the flora found on high mountains above the altitudinal limits of forests or trees or to designate the flora of the European Alps. In order to avoid ambiguity the phrase 'high mountain flora' or 'high mountain species' is used in this work for the flora and species occurring in the altitudinal zones 5b and 5c. The term 'Alpine'

[1] *Oesterr. Bot. Zeitschr.* lxxii. 231 (1923).

is restricted to species having a centre of distribution in the European Alpine system of mountains. Since, however, the immediate purpose is to trace the floristic connexions between the Alps and the mountains of the Balkan Peninsula we are, in this section, only concerned with high mountain plants. The necessity of thus defining the connotations of our terms will become evident below where it is shown, for example, that the Greek high mountain flora has very few Alpine species.

The total number of species which I have accepted as Alpine and which occur in zones 5b or 5c or in both in the Balkan Peninsula is 281. These occur in the different districts as follows: Crete 1, Greece 24, Thessaly 26, Epirus 28, Albania 108, North Macedonia 95, South Macedonia 27, Athos Peninsula 5, Thrace 3, North Bulgaria 112, South Bulgaria 4, Rodope massif 136, Dobruja 1, Serbia 130, Montenegro 173, Bosnia 171, Hercegovina 127, Dalmatia 71, South Croatia 146, Istria 43. The figures for Thrace, South Bulgaria, and the Dobruja are negligible, for the species are those which though normally high mountain in their distribution in the Balkan Peninsula occasionally have been found at lower altitudes. The great interest of the figures is the light they throw on the distribution of the high mountain Alpine species down the western side of the Balkan Peninsula and the extension eastwards. The following tabular arrangement expresses the facts most clearly.

Istria: 43 species. No very high mountains included in the district.
South Croatia: 146 species, together with
Bosnia: 171 species, forms the most important geographical link between the Balkan Peninsular and Alpine floras.
Hercegovina: 127 species. The high mountain area is sufficient for the occurrence of a large number of Alpine species in spite of the more Mediterranean type of general climate.
Dalmatia: 71 species. The high mountains are mostly near the Bosnian and Hercegovinian boundaries and the general climate is Mediterranean.
Montenegro: 173 species, the highest number of Alpine species of any district of the Balkan Peninsula. From here southwards the number decreases rapidly.
Albania: 108 species, mostly in the northern mountains.
Epirus: 28 species, a very large reduction, the high mountain flora here and for the following two districts is not Alpine in its essentials.
Greece: 24 species.
Crete: 1 species only; the Alpine flora is practically absent.

Eastwards from Bosnia there are 130 species known from Serbia and 112 from North Bulgaria, the latter almost entirely from the long

range of the Stara Planina. Here, however, it is difficult or impossible to separate the Alpine and Carpathian connexions for most of the species. From Albania eastwards we have North Macedonia with 95 species and the Rodope massif with 136 species; from Epirus eastwards, South Macedonia with 27 and Thessaly with 26. The last are mainly on the Pindus range and on Mt. Olympus. We thus find a massing of

Alpine species in Montenegro and a marked sudden decrease to the south. Obviously the main break is between Albania and Epirus as expressed in the above figures, but a more detailed analysis has revealed that the most important line of demarcation must be drawn in Albania itself somewhere near the latitude of Tirana. The botanical exploration of southern Albania and of Epirus has been less thorough than that of northern Albania and Montenegro, especially so far as the high mountain flora is concerned, and the figures for the former will probably be proportionately increased when further field collecting has been done. Of the 108 Alpine species known from Albania all are recorded from the northern mountains, and most of them from

the North Albanian Alps bordering on Montenegro. Several extend down near to the centre, but only 16 are recorded from mountains south of the latitude of Tirana. In the area of the North Albanian Alps there is a westward extension of the Serbian and North Macedonian high mountain flora, which is almost entirely endemic to the Balkan Peninsula. The data at present available are insufficient for a full analysis of this phenomenon. In order to see if a further sudden break occurred in Greece a detailed analysis of the 24 Alpine species of the high mountain flora of this district was made, but no such break was found. Twenty species occur north of the Gulf of Corinth, and 17 in the Peloponnese; 7 are limited to the north and 4 to the south.

A considerable number of the Alpine species of the Balkan Peninsula exhibit marked discontinuity in their distribution. A selection of examples will suffice:

Poa laxa Haenke 8, 8b.
Trisetum distichophyllum Pal. de Beauv. 11.
Carex curvula All. 8, 8b, 11.
C. fuliginosa Schkuhr 8b.
C. lachenalii Schkuhr 8, 11.
C. nigra Bell. 12.
Juncus triglumis L. 8b.
Luzula glabrata Desr. 8b.
L. spadicea Lam. et DC. 8, 8b.
Lloydia serotina Reichb. 8, 8b.
Salix herbacea L. 8b, 15.
S. lapponum L. 8, 8b.
S. myrsinites L. 6, 15.
Rumex nivalis Hegetsch. 5, 11.
Cerastium uniflorum Thomas 13.
Moehringia ciliata Dalla Torre 13.
Ranunculus crenatus W. et K. 5, 6, 8b, 11.
Cardamine resedifolia L. 6, 8b, 14.
Draba siliquosa Bieb. 8b.
Thlaspi alpinum Crantz 8, 8b.
Sedum roseum Scop. 8, 8b, 13.
Saxifraga androsacea L. 5, 8b, 12, 15.
Saxifraga bryoides L. 8b.
S. petraea L. 6, 15, 16.
S. retusa Gouan 8b.
Rosa cinnamomea L. 8, 8b.
Astragalus australis Lam. 8b, 11.
Oxytropis lapponica Gay. 5.
Viola pyrenaica Ram. 3, 4, 8b, 10.
Empetrum nigrum L. 8b, 11, 12.
Cortusa matthioli L. 8, 8b.
Swertia perennis L. 8b, 11.
Alectorolophus glacialis (Pers.) 11.
Euphrasia cuspidata Host 13.
Pedicularis oederi Vahl 8, 8b.
Wulfenia carinthiaca Jacq. 5, 11.
Plantago alpina L. 6, 6a.
Campanula alpina Jacq. 8, 8b.
C. spicata L. 11, 15.
Valeriana celtica L. 11.
Achillea stricta Schleich. 5, 11.
Artemisia laxa Fritsch 11.
Chrysanthemum lanceolatum Pers. 11.
Doronicum grandiflorum Lam. 13.
Hieracium glanduliferum Hoppe 11.
H. staticifolium All. 5.
Saussurea alpina DC. 8b.
S. discolor DC. 8b.
Willemetia stipitata Cass. 5, 6, 11.

The discontinuity of high mountain species is a well-known

phenomenon for many parts of the globe. For the Balkan Peninsula the geographical discontinuity of suitable habitats and the action of the ordinary agents of dispersal are sufficient to explain most of the examples. No doubt there was a lowering of the snow line during the Ice Age and a corresponding increase in the area colonized by what are now high mountain species, but this was certainly insufficient to bring about continuity in their distribution. With very few exceptions it is improbable that polytopy or polygenesis has occurred, because of the absence of likely parents of wider and more continuous distribution or the evidence for such having existed in the past. Some of the examples of discontinuous distribution are probably explained by more than one invasion from different directions or at different times. Thus many of the high mountain plants of the Balkan Peninsula are common to both the Alps and the Carpathians, and some have no doubt extended their distribution in different directions into the Balkan Peninsula from these mountain groups. Those species which are believed to show definite Carpathian connexions are dealt with in another section.

In order to appreciate at its proper value the relation between the high mountain flora of the Alps and that of the Balkan Peninsula a list is now given of species occurring in the Swiss portion of the former but not in the latter. The nomenclature is that of Schinz and Thellung, *Flora der Schweiz* (Zürich, 1923).

Sesleria ovata Kern.
S. sphaerocephala Ard.
S. disticha Pers.
Koeleria hirsuta Gaud.
Festuca alpina Suter.
F. rupicaprina Kern.
F. pulchella Schrad.
Trichophorum alpinum Pers.
T. pumilum Schinz et Thell.
Cobresia bipartita Dalla Torre.
Carex microglochin Wahlenb.
C. pauciflora Lightf.
C. rupestris Bell.
C. bicolor Bell.
C. atrofusca Schkuhr.
Juncus arcticus Willd.
J. castaneus Sm.
Luzula lutea Lam. et DC.
L. sudetica Lam. et DC.
Tofieldia palustris Huds.
Chamaeorchis alpina Rich.
Nigritella rubra Rich.
Salix albicans Schleich.
S. glauca L.
S. caesia Vill.
Betula nana L.
Dianthus glacialis Haenke.
Cerastium latifolium L.
C. pedunculatum Gaud.
Minuartia arctioides Schinz et Thell.
M. biflora Schinz et Thell.
M. rupestris Schinz et Thell.
M. rostrata Reichb.
Arenaria marschlinsii Koch.
Ranunculus glacialis L.
R. seguieri Vill.
R. alpestris L.
Thalictrum alpinum L.
Thlaspi virens Jord.

Cardamine alpina Willd.
Draba hoppeana Reichb.
D. ladina Braun-Blanquet.
D. fladnizensis Wulf.
D. tomentosa Clairv.
D. dubia Suter.
Arabis caerulea All.
A. pumila Jacq.
A. bellidifolia Jacq.
Sedum anacampseros L.
Saxifraga rudolphiana Hornsch.
S. biflora All.
S. aspera L.
S. muscoides All.
S. seguieri Spreng.
S. aphylla Sternb.
Potentilla multifida L.
P. nivea L.
P. grandiflora L.
Alchemilla pentaphylla L.
A. splendens Christ.
Trifolium alpinum L.
Astragalus alpinus L.
A. sempervirens Lam.
Phaca alpina L.
P. frigida L.
Oxytropis foetida DC.
O. triflora Hoppe.
Polygala alpina Steud.
Daphne striata Tratt.
Epilobium nutans Schmidt.
Primula viscosa All.
P. oenensis Thomas.
P. hirsuta All.
P. integrifolia L.
Androsace multiflora Mor.
A. helvetica All.
A. pubescens DC.
A. brevis Ces.
A. alpina Lam.
A. obtusifolia All.
A. chamaejasme Wulf.
A. septentrionalis L.
Gentiana prostrata Haenke.
G. brachyphylla Vill.
G. tergloviensis Hacq.
G. bavarica L.
G. rostanii Reut.
G. alpina Vill.
G. tenella Rottb.
G. ramosa Hegstsch.
Eritrichium nanum Schrad.
Erinus alpinus L.
Melampyrum laricetorum Kern.
Euphrasia alpina Lam.
Rhinanthus antiquus Schinz et Thell.
Pedicularis gyroflexa Vill.
P. rostrato-spicata Crantz.
P. recutita L.
P. tuberosa L.
P. ascendens Schleich.
P. foliosa L.
Valeriana supina Ard.
Phyteuma carestiae Biroli.
P. humile Schleich.
P. hemisphaericum L.
P. michelii All.
P. scaposum R. Schulz.
Campanula schleicheri Hegetsch.
C. cenisia L.
Adenostyles tomentosa Schinz et Thell.
Erigeron neglectus L.
E. glandulosus Hegetsch.
Antennaria carpatica R. Br.
Achillea nana L.
A. erba-rotta All.
Chrysanthemum alpinum L.
Artemisia genipi Weber.
A. glacialis L.
Cirsium spinosissimum Scop.
Hypochaeris uniflora Vill.
Crepis pygmaea L.
C. tergloviensis Kern.
C. rhaetica Hegetsch.

Several of the above species have been recorded from the Balkan Peninsula but the records are doubtful and I have not seen specimens of them. The list of 123 species would be considerably extended if species known from the high mountain zones of the eastern Alps (Tyrol, &c.) but not from the Swiss mountains or those of the Balkan Peninsula were included. Some of the species quoted are microspecies of limited distribution in the Alps and probably of recent origin, but others are characteristic Alpine species or have a wide general distribution. It is now generally acknowledged that the existing flora of the Alps consists of elements of very diverse origin in time and space and that the flora cannot be treated as a unit in considering its origin. Certainly the high mountain floras of the Alps and of the Balkan Peninsula show greater differences than might be expected from their relative geographical positions.

Of the many problems connected with the genesis of the Alpine flora, and with the high mountain floras of Europe in general, we are here only concerned with those affecting the flora of the Balkan Peninsula. There is, however, one wider subject which cannot be ignored entirely, namely, the relationship between the Arctic and Alpine floras. In order to avoid personal bias I have analysed the list of species chosen by Rikli as 'Arctic-Alpine' species for consideration in his paper published in the *Festschrift Carl Schröter*[1] pp. 97–9. There are 142 Phanerogams in the list, and of these 96 occur also in the mountains of the Balkan Peninsula, leaving 46 species which are common to the Alpine and Arctic regions but do not reach the Balkan Peninsula. The most noteworthy of these last are: *Cobresia caricina* Willd. (*Kobresia bipartita* Dalla Torre), 7 species of *Carex*, 3 species of *Juncus*, *Salix glauca* L., *Betula nana* L., *Minuartia biflora* Schinz et Thell., *Ranunculus glacialis* L., *Thalictrum alpinum* L., 3 species of *Saxifraga*, *Astragalus alpinus* L., *Androsace chamaejasme* L., *A. septentrionalis* L., *Trientalis europaea* L., and *Linnaea borealis* L. That the 'Arctic-Alpine' flora, as represented by the characteristic species of Rikli, has become reduced by nearly one-third in the Balkan Peninsula is additional strong evidence that relative to the Balkan Peninsula it has mainly come from the north. This is further emphasized by the fact that nearly all of the 'Arctic-Alpine' species occurring in our area are to be found in the mountains of the north-west and central parts of the Peninsula and not in those to the south.

A study of the high mountain flora of the Bithynian Olympus, which reaches to over 2,500 m. altitude, furnishes additional evidence of the dying out of Alpine species in a south-eastern direction. Thus after examining a carefully compiled list of the known flora of Olympus in

[1] Veröff. Geobot. Inst. Rübel Zürich, 3 Heft (1925).

Bithynia I find that only 29 species of mountain plants are common to this mountain, to any mountain of the Balkan Peninsula, and to the Alps. Most of these are widely distributed species which occur also in other mountains of Asia Minor and in the Caucasus, or occur also as lowland species over a wide and relatively continuous area. Few of them have reached Bithynia from the Alps, or have extended their distribution from Bithynia to the Alps via the Balkan Peninsula. The occurrence of *Bruckenthalia spiculifolia* Reichb. and *Gentiana bulgarica* Vel., both Balkan Peninsular types, on the Bithynian Olympus is of interest as indicating that floristic connexion between the high mountain floras is not prevented by geographical conditions.

The facts detailed in this section may now be summarized:

1. There are 281 representative species of high mountain plants common to the Balkan Peninsula and the European Alps.

2. These show their greatest concentration in the north-west, especially in Montenegro and Bosnia, and in the Rodope massif.

3. There is a well-marked break in the Alpine element of the high mountain flora in the central part of Albania, and in latitudes south of Tirana the Alpine element is very poor. Here the high mountain flora consists largely of endemics.

4. The evidence points to the view that the Alpine species, for the greater part, have extended their distribution southwards from the Alps and Carpathians into the mountains of the Balkan Peninsula. This extension probably reached a maximum in the Quaternary Ice Age.

5. There is little definite evidence that the flora of the Balkan Peninsula has contributed high mountain species as such to the flora of the Alps. It is probably more as genera than as species that any contributions have been made, and these probably in Tertiary times.

6. There is little definite evidence that the Balkan Peninsula has served as a route for species of the high mountain flora from the Caucasus, or Central Asia to the Alps. The Rodope is the only possible mountain link, and the greater part of its high mountain flora is either endemic or is connected with that of the Alps or Carpathians to the north and north-west.

CONNEXIONS WITH NORTH AFRICA WEST OF EGYPT (XVI.)

Tripoli and Cyrenaica are the nearest portions of the African continent to the Balkan Peninsula, and it will suffice to compare their flora with ours. The most complete work on the flora of Tripoli and Cyrenaica is that of Durand and Barratte. The following figures are taken from their 'Tableau synoptique':

Species from Tripoli only 228, of which 71 are known from Greece.

Species from Cyrenaica only 377, of which 261 are known from Greece.

Species from both areas, 378, of which 268 are known from Greece.

Totals: 983, of which 600 are known from Greece.

It should be explained that under Greece the authors include Greece proper, Crete, and the Cyclades.

The figures indicate one important fact, namely that the flora of Cyrenaica has a much closer affinity with that of the Balkan Peninsula than has the flora of Tripoli. The geographical position and the geological history of Cyrenaica explain this (see p. 33). Cyrenaica has a Mediterranean flora; that of Tripoli is 'Mediterraneo-subdesertica'. Of the 755 species recorded from Cyrenaica 529 occur also in the Balkan Peninsula and the great majority of these have a wide distribution, their distributional areas being or including either the Mediterranean Basin or the Mediterranean Region, as these are defined in this work. While some of these species may have become common to South Europe and North Africa by using Cyrenaica and the Balkan Peninsula as a dispersal route from the north or from the south, some, or even all, may just as likely have reached the two areas independently from the east or from the west. The same arguments hold good for a considerable number of species common to the two areas but with more limited general distribution. Cyrenaica forms an eastern limit to many western Mediterranean species, just as the Balkan Peninsula is shown elsewhere to do, though the flora of the Balkan Peninsula is more Oriental than that of Cyrenaica, and less western Mediterranean. The desert barrier to the east of Cyrenaica is now nearly as effective as an equal expanse of sea, but there is considerable evidence that within recent geological times the climatic conditions of northern Africa have changed much more than those of the Balkan Peninsula. To the west Cyrenaica is separated from the Mediterranean parts of Tunis and Algeria by the big bay stretching from the Gulf of Sidra to the Gulf of Gabes. The indirect connexion by the coastal strip of Tripoli is sufficient to account for the western Mediterranean element in its flora and for the fact that this is much greater than the Oriental element. It is only by a study of individual species that a direct floristic connexion between Tripoli and Cyrenaica and the Balkan Peninsula can be proved. The following species may indicate such a connexion. The relevant, and not necessarily the complete, distribution of each is given here.

Fumaria macrocarpa Parl. Cyr., Palestine, Syria, Crete, Greece, Cycl., S. Maced., Dalm.

Didesmus aegyptius Desv. Trip., Cyr., Egypt, Cyprus, Crete, Greece, Cycl.

Cistus parviflorus Lam. Cyr., Sicily, As. Min., Crete, Greece, Thrace.
Silene succulenta Forsk. Trip., Cyr., Tunis, Egypt, Syria, Crete.
Fagonia cretica L. Trip., Cyr., Spain, Morocco, Algeria, Tunis, Egypt, Cyprus, Crete.
Medicago disciformis DC. Cyr., Italy, France, Spain, As. Min., Crete, Greece, Cycl., Corfu, N. Maced., S. Maced., Thrace, Herceg., S. Croat., Istria.
Trifolium uniflorum L. Cyr., Sicily, As. Min., Crete, Greece, Cycl., S. Maced., Athos Penins., Thrace, Thracian Is., Dalm.
T. formosum Urv. Cyr., Egypt, Palestine, Syria, Irak, Persia, Crete, Greece, Cycl., Thrace.
Onobrychis crista-galli Lam. Cyr., Morocco, Alg., Tunis, Egypt, Palestine, Syria, Crete, Greece, Thrace.
Ceratonia siliqua L. Trip., Cyr., Alg., Palestine, Syria, As. Min., Crete, Greece, Cycl., Dalm., Istria.
Poterium spinosum L. Italy, Tunis, Trip., Cyr., Palestine, Syria, As. Min., Crete, Greece, Cycl., Thessaly, Epirus, Corfu, N. Maced., S. Maced., Athos Penins., Thrace, Thracian Is., Mtn., Herceg., Dalm., S. Croatia.
Scaligeria cretica Vis. Cyr., Palestine, Syria, As. Min., Crete, Greece, Cycl:, Thessaly, Epirus, Corfu, Alb., Athos Penins., Dalm.
Sedum creticum Boiss. et Heldr. Cyr., Crete.
Saxifraga hederacea L. Cyr., Sicily, Syria, As. Min., Crete, Greece, S. Maced., Athos Penins., Dalm.
Pterocephalus papposus Coult. Marmaric coast, Egypt, Arabia, Palestine, Syria, Irak, Persia, Crete.
Rubia olivieri Rich. Marmaric coast, Palestine, Syria, As. Min., Crete, Greece, Thrace.
Cynara sibthorpiana Boiss. et Heldr. Trip., Cyr., Egypt, Palestine, Cyprus, Crete, Greece.
Cichorium spinosum L. Cyr., Sicily, Spain, Cyprus, Rhodes, Crete, Greece, Cycl.
Convolvulus oleifolius Desf. Trip., Cyr., Egypt, Cyprus, Rhodes, Crete, Greece, Cycl.
Echium sericeum Vahl. Trip., Cyr., Tunis, Egypt, Cyprus, Rhodes, Crete, Greece, Cycl., Thrace.
E. elegans Lehm. Cyr., Palestine, Syria, As. Min., Crete, Greece, Cycl., Thrace.
Anchusa aegyptiaca A. DC. Tunis, Egypt, Palestine, Syria, Irak, Persia, Crete, Greece, Cycl.
Calamintha incana Boiss. Cyr., Palestine, Syria, As. Min., Greece, Cycl.
Salvia triloba L. Cyr., Italy, Palestine, Syria, As. Min., Crete, Greece, Cycl., Corfu, Thrace, Herceg.

Sideritis purpurea Talbot. Cyr., As. Min., Crete, Greece, Thessaly, Epirus, Corfu, Alb., S. Maced., Mtn., Herceg., Dalm.

Ballota pseudo-dictamnus L. Cyr., Crete.

Stachys tournefortii Poir. Cyr., Crete, Thrace.

Teucrium brevifolium Schreb. Cyr., Crete, Greece, Cycl.

T. divaricatum Sieb. Cyr., Palestine, Syria, As. Min., Crete, Greece, Cycl., Thessaly, Athos Penins., Thrace.

Limonium graecum O. Ktze. Cyr., Syria, As. Min., Crete, Greece, Cycl., S. Maced., Athos Penins., Thrace, N. Maced., S. Maced., Dobr., Serb.

Typha angustata Bory et Chaub. Trip., Cyr., Egypt, Arabia, Syria, Persia, Crete, Greece, Cycl., Thessaly, Epirus, Corfu, Alb., S. Maced., Thrace, Dobr., Dalm.

Catapodium tuberculosa Moris. Cyr., Sicily, Sard., Morocco, Alg., Tunis, Palestine, Greece.

Elymus delileanus Schult. Cyr., Egypt, Palestine, Syria, Irak, Persia, Crete.

Cupressus sempervirens L. Cyr., Syria, Persia, As. Min., Crete, Gaudhos, Greece, Alb., Athos Penins., Thrace.

Ephedra campylopoda C. A. Mey. Cyr., Palestine, Syria, As. Min., Crete, Greece, Cycl., Thessaly, Epirus, Corfu, Alb., N. Maced., S. Maced., Athos Penins., Thrace, Mtn., Bosn., Herceg., Dalm.

The above species number only 35. There are about half a dozen more which may later have to be included, but as I am at present doubtful of their identification and have not specimens available I have left them out. Considering the size of the floras involved the list is a meagre one. It is to be noted that only three [1] of the species have an entirely North African and Balkan Peninsular distribution. It must be concluded that there has been no close floristic connexion directly between North Africa and the Balkan Peninsula within recent geological times. The widely distributed Mediterranean species are on the whole probably relatively old, and it is possible that many of them used a Cyrenaican-Cretan-Aegean land mass in extending their distribution. All the phytogeographical evidence points, however, to this having been of much less importance for the flora of the Balkan Peninsula than the Aegean connexion between Greece and Asia Minor. Indeed the importance has perhaps been greater for the Cyrenaican flora than for that of the Balkan Peninsula.

In addition to the species enumerated above the following deserve mention:

Haynaldia hordeacea Hack. described originally from mountainous

[1] Four species if *Haynaldia hordeacea* Hack. be included.

districts in Morocco and Algeria has been discovered in the Taygetus mountains in the south of Greece, and *Koeleria hispida* DC. which is known from Algeria, Tunis, Egypt, Italy, Sicily, Sardinia, Corfu, Zante, and Aetolia.

Anagallis platyphylla Bando, which I found in South Macedonia, was almost certainly introduced with army fodder from North Africa.

When the distributional figures and details are carefully compared it is seen very clearly that North Africa has less floristic connexion with the Balkan Peninsula than have countries to the east, north, and even west of the Peninsula. Southern lines of dispersal from or into our area have been the least important.

It is of interest here to recall Hagen's argument [1] that the North Temperate Zone, at least from middle Tertiary times onwards, has always had a dry climatic belt. This has not always been of the same intensity, certainly it has not always been desert as the Sahara is to-day. Often it has been more temperate as half-desert, desert-steppe, or steppe, or has been broken up into separate parts. This dry zone has swung north and south, for traces of it in Oligocene and Miocene times have been found to the north, and in Diluvial times to the south, of the present desert area.

CONNECTIONS WITH EGYPT (XVII).

The floristic connexions of our area with North Africa west of Egypt, even with Cyrenaica and Tripoli, have been shown above to be much less strong than would be expected merely on the grounds of geographical position. They are, for example, very much less important than the botanical connexion between Spain and north-west Africa. The connexions with Egypt are less important still. Excluding the species with a wide distribution common to many or several Mediterranean districts there are very few species which indicate a floristic connexion between Egypt and the Balkan Peninsula. The species placed in the category XVII. for the most part extend into other areas as well, and may or may not have entered the Balkan Peninsula from Egypt. The early Minoan commercial connexions between Egypt and Crete might lead one to expect that a considerable number of species would be intentionally or accidentally introduced. I have found no definite evidence for this. The following species are the only ones I know which are common to Egypt and the Balkan Peninsula, and which very probably reached one of these areas from the other: *Lolium compressum* Boiss. et Heldr., *Enarthrocarpus lyratus* Forsk. (also from the Sudan), and *Convolvulus lanatus* Vahl (also from Arabia Petraea). *Fumaria judaica* Boiss. may have been introduced into the

[1] *Mitt. Geogr. Ges. München*, ix. 152 (1914).

Balkan Peninsula from Egypt, or from Palestine or Syria. *Centaurea pullata* L., which I recorded from South Macedonia, was probably introduced with army fodder from Egypt or the western Mediterranean Basin. These three or four species are practically negligible as positive evidence and their extreme fewness confirms the conclusion, reached in the last section, that there has been no geologically recent direct connexion between the floras of the Balkan Peninsula and North Africa.

CAUCASIAN AFFINITIES OF THE BALKAN PENINSULAR FLORA (XVIII).

In attempting to trace the relationships between the floras of the Caucasus and the Balkan Peninsula the difficulties encountered were such that several methods had to be adopted. In the tables under the category XVIII. are counted all those species occurring in the Balkan Peninsula, whose general distribution is IV, or any figure-symbol from this to XIX., and which occur also in the Caucasus, as this area is accepted in W. I. Lipsky's *Flora Caucasica*,[1] as well as those with XVIII. only for their general distribution. The figures alone are therefore misleading unless this explanation is remembered. The total and the figures for each family merely indicate the number of species, excluding the 'wides', common to the Balkan Peninsula and the Caucasus. The number, 1,063, proves that there is an important basic resemblance between the two floras, but it does not prove that any considerable proportion of the species has reached one area from the other. In both areas, as here accepted, Mediterranean and Central European species and vegetational communities meet, and the high percentage of common species is partly accounted for by this fact.

Before considering further the real affinities it is necessary to extract those species suggesting a direct floristic connexion between the Balkan Peninsula and the Caucasus. The list is short (13 species), and may therefore be given in full, with the Balkan Peninsular distribution of each species.

Carex phyllostachys C. A. Mey. 6 (and N.-E. Persia).
Ornithogalum arcuatum Steven. 8a.
O. refractum Kit. 6, 6a, 7, 8, 8a, 9, 10, 13, 14, 16.
O. tenella Ledeb. 8, 8a, 10.
Arabis mollis Steven. 8.
Saxifraga juniperifolia Adams. 8, 8b (as vars. *pseudosancta* Engl. et Irm. and *macedonica* Engl. et Irm.).
Genista patula Bieb. 8.
Linum thracicum Degen. 6, 6a, 7, 8, 8a, 8b, 10, 11 (somewhat doubtful if the Caucasian plant is exactly the same).

[1] Acta Hort. Tiflis, iv. (1899).

Helianthemum lasiocarpum Willk. 6, 6a, 8a, 9, 10 (and Cilicia).
Anchusa thessala Boiss. et Sprun. 3, 7, 8a.
Salvia ringens S. et S. 2, 3a, 5, 6, 6a, 8, 8a, 8b, 9.
Swertia punctata Baumg. 8, 8b, 10.
Carduus seminudus Bieb. 8b (as var. *thracicus* Vel.), and Caspian.

I have not actually seen specimens from both the Balkan Peninsula and the Caucasus of all the above species, and possibly some should be eliminated. However, the evidence is clear that there is little direct connexion between the flora of the Caucasus and that of the Balkan Peninsula. Only 13 species suggest a direct linkage, and some, at least, of these may occur in northern Asia Minor, although not yet recorded. This floristic evidence supports the geological evidence that the Black Sea is relatively old, and that, in spite of their opposite terminations, the Stara Planina has had no junction with the Caucasus (or Crimea) across what is now sea. The evidence for extensions of Caucasian species across the northern parts of Asia Minor and also through South Russia into the Balkan Peninsula is, on the other hand, clearly positive, as is shown by the next three lists.

Species which indicate a connexion between the Balkan Peninsular and Caucasian floras via Asia Minor, especially the northern parts.

Juniperus excelsa Bieb. 6, 6a, 7, 8b.
J. foetidissima Willd. 2, 3, 3b, 4, 5, 6, 6b.
Ventenata macra Bal. 2.
Arum orientale Bieb. 2, 2a, 6a, 7, 8a, 11, 13, 14.
Allium cilicicum Boiss. 8a.
Merendera caucasica Bieb. 8, 8a.
Ornithogalum oligophyllum Clarke. 2, 3b, 4, 5, 6, 7, 8.
Smilax excelsa L. 6a, 6b, 7, 7a, 8, 8a.
Cephalanthera cucullata Boiss. et Heldr. 1, 7.
Ophrys oestrifera Bieb. 1, 2, 7.
Fagus orientalis Lipsky. 8, 8a, 8b, 9.
Celtis caucasica Willd. 8, 8a.
Arenaria gypsophiloides L. 8a, 8b.
A. rotundifolia Bieb. 3a, 5, 6, 6b, 7a, 8, 8b, 10, 11.
Dianthus calocephalus Boiss. 6, 7.
D. pallens S. et S. 2, 3, 3a, 4a, 6, 6a, 7, 7a, 8, 8a, 8b, 9, 10.
Silene compacta Friv. 3, 6, 6b, 7, 8a, 8b, 9.
Telephium orientale Boiss. 1, 2, 3b.
Tunica pachygona Fisch. et Mey. 3, 6a, 7.
Anemone blanda Schott et Kotschy. 2, 2a, 3a, 4a, 5, 6, 6a, 7, 8b.
Delphinium subvelutinum Heldr. 2a, 5, 6a, 7.

Nigella orientalis L. 7.
Ranunculus constantinopolitanus Urv. 7, 8, 8a.
R. lomatocarpus Fisch. et Mey. 7.
R. marginatus Urv. 2, 3, 5, 6a, 7, 8b.
R. ophioglossifolius Vill. 1, 2, 2a, 3b, 4a, 5, 6, 6a, 6b, 7, 8a, 10, 11, 12, 14, 16.
Epimedium pubigerum Mor. et DC. 7, 8a.
Iberis taurica DC. 7.
Prunus laurocerasus L. 7, 8, 8a, 10.
Dorycnium latifolium Willd. 2, 3, 6a, 6b, 7, 8.
Orobus aureus Steven. 8, 8a, 9.
Pistacia mutica Fisch. et Mey. 7, 8a.
Althaea armeniaca Ten. 7.
Tamarix tetrandra Pall. 1, 2, 6a, 7, 8a.
Daphne pontica L. 7, 8b.
Bupleurum gracile DC. 2, 2a, 3, 6a, 7, 8, 8a.
Rhododendron ponticum L. 8a.
Vaccinium arctostaphylos L. 8a.
Trachystemon orientale Don. 7, 8a.
Stachys lanata Jacq. 7, 7a.
Hyoscyamus reticulatus L. 1, 7.
Galium tenuissimum Bieb. 6, 7, 8, 8a, 10.
Knautia orientalis L. 2, 3, 3b, 6, 6a, 7, 8, 8a, 8b.
Pterocephalus plumosus Coult. 1, 2, 3, 5, 6, 6a, 7, 8, 8a.
Campanula lyrata Lam. 7.
Legousia pentagonia Thell. 1, 2a, 4a, 7.
Crepis parviflora Desf. 7.
Lapsana intermedia Bieb. 6a, 6b, 7.
Scorzonera lanata Bieb. 2, 6a, 7, 8a.

Species which indicate a connexion between the Balkan Peninsular and Caucasian floras via the Crimea and S. Russia.

Elymus sabulosus Bieb. 6, 7, 8, 8a, 9.
Juncellus pannonicus C. B. Clarke. 5, 8, 9, 10.
Asparagus brachyphyllus Turcz. 9.
Fritillaria tenella Bieb. 5, 8, 8a, 9, 10, 11, 12, 13, 14, 15, 16.
Hyacinthus leucophaeus Steven. 8, 8a, 8b, 10.
Tulipa biebersteiniana R. et S. 9.
Crocus reticulatus Steven. 8, 9, 10, 11, 13, 14, 16.
Dianthus campestris Bieb. 8, 8a.
D. capitatus Balb. 6, 8, 8b, 9, 10.
D. leptopetalus Willd. 6a, 7, 9.
D. pseudarmeria Bieb. 6a, 7, 8, 8a, 9.
Gypsophila glomerata Pall. 8, 8a, 9.

Minuartia glomerata Degen. 6, 6a, 7, 8, 8a, 8b, 9, 10.
Paronychia cephalotes Besser. 3b, 6, 6a, 7, 8, 8b, 9, 10.
Silene cserei Baumg. 8, 8b, 9.
S. wolgensis Otth. 8, 9.
Delphinium divaricatum Ledeb. 8, 8a, 9.
Paeonia tenuifolia L. 8, 8a, 9, 10.
Ranunculus oxyspermus Bieb. 8, 8a, 8b, 9.
Alyssum obtusifolium Steven. 9.
Bunias orientalis L. 6, 9, 10.
Erysimum canum Koch. 9, 10.
Crataegus pentagyna W. et K. 5, 6, 7, 8, 8a, 10, 13.
Pyrus elaeagnifolia Pall. 9.
Astragalus diffusus Willd. 9.
Genista albida Willd. 9.
Erodium serotinum Steven. 9.
Linum tauricum Willd. 5, 6, 7, 8, 8a, 9, 10.
Euphorbia petrophylla C. A. Mey. 9.
Trinia henningii Hoffm. 9.
Echium rubrum Jacq. 5, 6, 8, 8a, 9, 10.
Symphytum tauricum Willd. 8, 8a, 9.
Stachys sideritoides Koch. 5, 6a, 8, 8b, 9.
Verbascum speciosum Schrad. 6a, 8, 8a, 9, 10, 11, 12.
Veronica orchidea Crantz. 5, 8, 8a, 8b, 9, 10.
Asperula tyraica Besser. 8, 8a, 9.
Dipsacus pilosus L. 8, 9, 10, 11, 12.
Achillea leptophylla Bieb. 8, 9.
Artemisia arenaria DC. 9.
Centaurea arenaria Bieb. 7, 8, 8a, 9.
C. marschalliana Spreng. 8, 9.
C. orientalis L. 6, 8, 8a, 8b, 9, 10.
C. oviceps Bornm. 8a, 9.
C. stenolepis Kern. 5, 6a, 8, 8a, 8b, 9, 10, 11, 12, 13.
C. sterilis Steven. 8, 10.
Chrysanthemum millefoliatum L. 8, 9.
Crepis rigida W. et K. 8, 9, 10, 11, 12, 13, 15, 16.
Sonchus uliginosus Bieb. 8, 8a, 8b, 9, 10, 11, 13, 15.
Tragopogon campester Besser. 6, 8, 8a, 9.

Species which indicate a probable connexion between the Balkan Peninsular and Caucasian floras via the districts both north and south of the Black Sea.

Oryzopsis holciformis Richt. 2, 8, 8a, 8b, 9, 10.
Asparagus verticillatus L. 2, 5, 6, 7, 8, 8a, 9.

Sternbergia colchiciflora W. et K. 2, 3, 3b, 4, 7, 8, 8a, 8b, 9, 10, 14.
Silene dichotoma Ehrh. 1, 6, 7, 8, 8a, 8b, 9, 10, 12, 15.
S. longiflora Ehrh. 2, 3, 3b, 4, 5, 6, 6a, 7, 8, 8a, 8b, 9, 10, 12, 13.
Delphinium paniculatum Host. 2, 3, 3b, 4, 5, 6, 6a, 7, 8, 8a, 9, 10, 11, 12, 13, 14, 15, 16.
Alyssum minutum Schlecht. 1, 2, 3, 6, 6a, 7, 8, 8a, 9, 10.
A. tortuosum W. et K. 6, 7, 8, 8a, 8b, 9, 10.
Astragalus ponticus Pall. 6a, 7, 8, 9.
Linum hirsutum L. 5, 6, 6a, 7, 8, 8a, 9, 10, 14, 15.
Euphorbia glareosa Pall. 6, 7, 8, 8a, 9, 10.
Tamarix pallasii Desv. 1, 2, 3, 4, 5, 6, 6a, 7, 8a, 9.
Heliotropium suaveolens Bieb. 2a, 3, 5, 6, 6a, 7, 8, 8a, 8b, 9.
Ajuga laxmannii Benth. 6, 6a, 7, 8, 8a, 8b, 9, 10, 11.
Marrubium praecox Janka. 8, 8a, 9.
Artemisia annua L. 6a, 7, 8, 8a, 9, 10, 11, 12.
Centaurea diffusa Lam. 3, 3a, 6, 6a, 6b, 7, 8, 8a, 8b, 9, 16.
C. salonitana Vis. 1, 2, 2a, 3, 3a, 3b, 4, 5, 6, 7, 8, 8a, 8b, 9, 10, 11, 14, 15.
Scorzonera mollis Bieb. 1, 2, 2a, 4, 4a, 6, 6a, 7, 8a, 8b, 9.
Taraxacum serotinum Poir. 6, 6a, 7, 8, 8a, 8b, 9, 10.

In addition to the above lists the section dealing with the Pontic affinities of the Balkan Peninsular flora should be consulted. It is also relevant that a number of Balkan Peninsular endemics have their nearest morphological affinities in the Caucasus. Examples are: *Narthecium scardicum* Košanin, *Dioscorea balcanica* Košanin, and *Sesleria dorfleri* Hayek. With very few exceptions, the woody plants indicating a connexion between the Caucasian and Balkan Peninsular floras have a distribution across northern Asia Minor and not across southern Russia. Finally attention may be called to the considerable number of old types, species or genera, often referred to as 'Tertiary relicts' common to the Caucasian and Balkan Peninsular floras. Many of these also are woody plants, and the following are examples: *Prunus laurocerasus* L., *Laurus nobilis* L., *Rhododendron ponticum* L., and species of *Carpinus*, *Ostrya*, *Celtis*, *Zelkova*, *Juglans*, *Zizyphus*, *Acer*, *Vitis*, *Cornus*, and *Symphyandra*.

BALKAN PENINSULAR TYPES (XIX.).

There are 274 species in our flora which have such a distribution that it is a fair judgement to consider them as having originated in the Balkan Peninsula and spread a short distance beyond its borders, often in more than one direction. The category is a necessary one in a complete analysis of the flora, but it is difficult to know sometimes whether to include or exclude a certain species. Those included have not all

the same general type of distribution, for some are limited and some are widespread within the Balkan Peninsula itself. Some have spread just over into Asia Minor, others just into Italy, others into Roumania, and still others into pre-war Hungarian territory beyond our boundaries. The category as a whole is most closely related to the category of endemics, and it might be argued that they should be considered with the species strictly limited to the Balkan Peninsula. The problems of endemism, however, are of exceptional phytogeographical interest, and I have thought it best to keep the endemic category very strictly defined. Since at its northern limits the Balkan Peninsula has no well-marked natural boundaries of phytogeographical importance the endemic category itself is to some extent artificial. The northern parts, however, are by far the poorest in endemics, and even if the Balkan Peninsular types were added to the endemics this would still be true. It follows that the sharp definition of the endemic category gives less artificial results than it would with a different distribution within the Peninsula of the species concerned. It will suffice to give examples, with their known distributions, of the species included in the category of Balkan Peninsular types.

Aegilops uniaristata Vis. 11, 14, 15, 16. Italy.
Alopecurus creticus Trin. 1, 3, 4a, 7, 11. Lydia.
Erianthus hostii Griseb. 3, 5, 6a, 7, 8, 8a, 9, 10, 11, 14. Hungary, Banat, Slavonia, Asia Minor, Syria.
Koeleria nitidula Vel. 6, 6a, 6b, 7, 8, 8a, 8b, 10. Czecho-Slovakia, Asia Minor, Caucasus.
Maillea crypsoides Boiss. 2, 2a. Chios, Rhodes, and a variety (?) from Sardinia.
Phacelurus digitatus Griseb. 2, 3, 5, 6a, 7, 8a. Asia Minor.
Sesleria autumnalis F. Schultz. 11, 12, 13, 14, 15, 16. Crimea and N.-W. Italy.
S. rigida Heuff. 6, 8, 8a, 8b, 10. Banat, Hungary, Transylvania.
Muscari pulchellum Heldr. et Sart. 2, 2a, 6, 7, 8a, 10. Doubtfully from Syria and Persia.
Ornithogalum boucheanum Aschers. 6, 7, 8, 8a, 9. Bessarabia, Asia Minor.
Galanthus graecus Orph. 6, 6a, 7, 8, 8a, 8b, 10. Chios.
Crocus aureus S. et S. 6, 6a, 6b, 7, 8, 8a, 8b, 9, 10. S. Hungary, Roumania, Asia Minor.
C. chrysanthus Herb. 2, 6, 6a, 7, 8, 8a, 8b, 9, 10. Asia Minor.
C. olivieri Gay. 1, 2, 2a, 6a, 7, 8a. Roumania, Asia Minor.
C. pulchellus Herb. 6a, 6b, 7, 8a, 8b. N.-W. Asia Minor.
C. sieberi Gay. 1, 2, 3, 6a, 12. Asia Minor.

Iris reichenbachii Heuff. 5, 6, 6a, 8, 8a, 8b, 10, 11, 12, 13. Banat.
I. sintenisii Janka. 1, 2, 3, 4, 5, 6a, 7, 8, 8a, 9, 10. S. Italy, Asia Minor?
I. variegata L. 5, 8, 8a, 8b, 9, 10, 11, 12, 15. Austria, Hungary.
Ophrys cornuta Steven. 1, 2, 2a, 4, 4a, 5, 6, 6a, 7, 8, 8a, 10, 11, 12, 13, 14, 16. Banat, Roumania, Asia Minor, Transcaucasia.
Salix amplexicaulis Bory et Chaub. 2, 3, 6, 6a, 8, 8a, 16. Asia Minor.
Comandra elegans Reichb. 2, 3, 5, 6, 6a, 7, 8, 8a, 8b, 10. Banat, Bithynia.
Rumex triangularis DC. 1, 2, 3, 4, 5, 12, 13, 14. Italy, Sicily.
Dianthus armeriastrum Wolfner. 5, 6, 6a, 8, 8a, 8b, 10, 11, 12, 13, 15. Hungary, Transylvania.
D. corymbosus S. et S. 3, 6, 6a, 7, 8, 8a, 8b, 10, 11, 12. Asia Minor.
D. giganteus Urv. 7, 8, 8a, 8b, 9, 10, 12. Banat, Transylvania.
Drypis spinosa L. 2, 3, 4, 5, 6, 11, 12, 13, 14, 15, 16. N.-E. Italy, Carniola.
Kohlrauschia glumacea Hayek. 1, 2, 3, 4, 4a, 5, 6, 6a, 7, 8, 10, 11, 13, 14, 15. Lesbos.
Scleranthus neglectus Roch. 2, 2a, 3, 3b, 4, 5, 6, 6a, 7a, 8, 8b, 10, 11, 12. Italy, Sicily, Transylvania, Asia Minor.
Silene coesia S. et S. 2, 3, 4, 5, 7. Samos, Chios.
S. lerchenfeldiana Baumg. 6, 6a, 8, 8b, 10. Transylvania, Banat, Roumania.
S. trinervia Seb. et Maur. 2, 3, 4, 5, 6, 6a, 7, 8, 8a, 8b, 10, 11, 13, 14, 15. Banat, Central Italy.
Tunica illyrica Fisch. et Mey. 2, 3, 4, 5, 6, 6a, 8, 8a, 8b, 10, 11. S. Italy, Sicily, Roumania, N. Africa.
Viscaria atropurpurea Griseb. 6, 6a, 8, 8a, 8b, 10. Just into S. Hungary.
Delphinium fissum W. et K. 5, 7, 8, 8a, 9, 10, 11, 12, 13, 14, 16. Carniola, Croatia, Banat, Transylvania.
Helleborus multifidus Vis. 11, 12, 13, 14, 15. S. Italy, Sicily, S. Hungary.
Paeonia peregrina Mill. 5, 6, 6a, 7, 8, 8a, 9, 10, 11, 15, 16. Croatia, Asia Minor.
Ranunculus psilostachys Griseb. 2, 3, 4, 5, 6, 6a, 6b, 7, 8, 8a, 8b, 10, 11, 12. Asia Minor, Central Italy.
Fumaria thuretii Boiss. 1, 2, 3, 6, 6a, 10, 11, 13, 14. Cyprus, Banat.
Arabis scopoliana Boiss. 11, 12, 13, 14, 15, 16. North to Nanos.
Nasturtium lippizense DC. 4, 5, 6, 6a, 7, 8, 8a, 10, 10a, 11, 12, 13, 14, 15, 16. Carniola, Carinthia.
Peltaria alliacea Jacq. 5, 9, 11, 12, 13, 14, 15, 16. North to Styria and Transylvania.
Thlaspi praecox Wulf. 6, 7, 8, 8a, 8b, 11, 12, 13, 14, 15, 16. Italy, S. Tyrol, Carniola.

Vesicaria graeca Reut. 2, 3, 5, 6, 6a, 6b, 8, 8b, 11, 12, 13, 14, 15. Italy, Bithynia.

Cotyledon chlorantha Hal. 1, 2, 3, 4a, 11, 14. Cos, Smyrna.

Saxifraga marginata Sternb. 2, 3, 4, 5, 6, 8, 10, 11, 12, 13, 14, 15. S. Italy, Carpathians.

S. porophylla Bert. 2, 3, 4, 5, 6, 6a, 6b, 8b, 10, 11. Bithynian Olympus, Italy.

Spiraea cana W. et K. 10, 12, 13, 14, 15. Friuli, Asia Minor, Armenia.

Genista sericea Wulf. 2, 5, 10, 11, 12, 13, 14, 15, 16. North to Carniola and S. Tyrol.

Onobrychis alba Desv. 2, 3, 4, 5, 6, 6a, 8, 8a, 8b, 10, 11, 12, 13, 14. Banat, Roumania.

Trifolium praetutianum Guss. 4, 5, 13. S. Italy, Roumania (?).

Vicia oroboides Wulf. 12, 13, 15, 16. S. Tyrol, Lower Austria, Styria, Roumania.

V. salaminia Heldr. et Sart. 1, 2, 2a, 3, 7. Lesbos.

Geranium caeruleatum Schur. 5, 11, 12. Transylvania.

Linum elegans Sprun. 2, 3, 6a, 6b, 7, 8b, 13, 14. Troas.

Ruta patavina L. 5, 12, 13, 14, 15, 16. N. Italy, Carniola.

R. suaveolens DC. 6, 8, 8a, 8b, 9, 10. Roumania, Transylvania.

Euphorbia veneta Willd. 2, 3, 5, 6a, 7, 11, 13, 14, 15, 16. North to Friuli.

Tilia tomentosa Moench. 2, 3, 4, 5, 6, 6a, 7, 8, 8a, 8b, 9, 10, 11, 12, 13, 14, 15. Bithynia and north to Hungary and Moldavia.

Althaea taurinensis DC. 6, 8a, 10, 14, 16. N. Italy.

Hypericum rhodopeum Friv. 6, 6a, 6b, 7, 8, 8a, 8b. Bithynia, Troas.

Bupleurum aristatum Bartl. 4, 5, 6, 10, 10a, 11, 12, 13, 14, 15, 16. N. to Krain, S. Tyrol, N. Italy.

Freyera cynapioides Guss. 5, 6, 10, 11, 12, 13. S. Italy.

Bruckenthalia spiculifolia Reichb. 6, 6a, 8, 8b, 10. Transylvania, Banat, N. Asia Minor.

Gentiana bulgarica Vel. 5, 6, 8, 8b, 10. Transylvania, Bithynian Olympus.

Anchusa barrelieri Vitm. 5, 7, 8, 8b, 9, 10, 11, 12, 13. Italy, Transylvania, S. Russia, Asia Minor.

Anchusa osmanica Vel. 6a, 7, 8, 8a, 8b, 11. North to Silesia, Bessarabia.

Echium pustulatum S. et S. 1, 2, 2a, 5, 6a, 14, 15, 16. Italy, Sicily.

Symphytum ottomanum Friv. 2, 3, 4, 6, 6a, 6b, 7, 8, 8a, 8b. Banat.

Salvia argentea L. 1, 2, 3, 4, 6, 8, 8b, 10, 14. Troas.

Satureia caerulea Janka. 8, 8a, 8b, 9. Roumania.

Thymus zygioides Griseb. 6, 6a, 7, 8, 8a, 8b, 9, 10. Roumania, Asia Minor.

Verbascum glabratum Friv. 5, 6, 8, 8a, 8b, 11, 12, 13, 14. Banat.

Knautia macedonica Griseb. 5, 6, 6a, 8, 8a, 8b, 9, 10. Carinthia, Roumania.

Hedraeanthus graminifolius DC. 2, 3, 4, 5, 6, 10, 11, 12, 13, 14, 15. Italy, Sicily, Transylvania.

Anthemis brachycentros Gay. 2, 3, 4, 4a, 5, 6a, 7, 8b, 11, 12, 13, 14, 15, 16. Bithynia.

Crepis chondrilloides Jacq. 11, 12, 13, 14, 15, 16. North to Carniola.

Scorzonera villosa Scop. 5, 9, 11, 12, 13, 14, 15, 16. N. Italy, Transylvania.

The examples given above indicate very clearly the undoubted fact that each species in a flora is influenced by, or reacts in a unique manner to, a combination of factors peculiar to itself, this resulting in a distribution not exactly like that of any other species. The same fact is indicated with equal clearness by a detailed study of the endemism of the Balkan Peninsular flora. It is important therefore to realize that the categories, for general distribution, have only the defined degree of accuracy, and lead only to the differentiation of the main lines of extension, or migration, and of some of those factors which aid or limit the distribution of species.

The chief routes of plant migration. Thickness of arrows indicates importance.

XIV

ENDEMIC AND RELICT SPECIES AND THE AGE AND AREA HYPOTHESIS

General. The high importance of endemics in the Balkan Peninsular flora is one of its many striking features. This is quite evident in herbarium studies but is emphasized by field work, because quite often endemics are numerous as individuals and are even locally dominant in plant communities. In phytogeographical work endemic species are usually considered to be of special interest. Certainly they raise questions of the greatest import, which cannot always be answered with such definiteness as could be wished, owing, usually, to the absence of palaeontological data. I therefore considered it essential to analyse very carefully the endemics in our area. A summary of the results obtained and the conclusions drawn from them is given below.

It is of interest first to consider the taxonomic distribution of the endemic species. For this purpose two tables are given. In the first all the 1754 endemics are included and their distribution in families in the districts indicated. By 'endemics' in this table are meant all those species whose known distribution is entirely within the boundaries of the Balkan Peninsula as accepted in this work and detailed in Chapter I. The second table includes only the 901 species which occur each in one district only of the Balkan Peninsula.

A study of the figures and their graphic representation on the two maps discloses some significant facts. The highest number of Balkan Peninsular endemics occurs in Greece. Since, owing to its peninsular shape, this district has a relatively short land boundary it might be expected that a large number of those endemics which have arisen in the district have not spread beyond it. Two hundred and sixty or 46 per cent. of the Balkan Peninsular endemics in Greece are, indeed, endemic to the district. Crete, an island district but with a much smaller area and less diversified environmental conditions, has 131 endemics confined to the district out of 201 Balkan Peninsular endemics occurring within the district, or 65 per cent. Contrasting with these figures, especially as expressed in percentages, we note that Albania has 318 Balkan Peninsular and only 46 district endemics, North Macedonia 309 and 54, and the Rodopes 286 and 47. The corresponding percentages are: for Albania, with land connexions on three sides, 14 per cent.; for North Macedonia 17 per cent.; and for the Rodopes 16 per cent. The two last districts have entirely land boundaries. While the three last mentioned districts have, after Greece, the highest absolute numbers of Balkan Peninsular endemics, and indeed form most important

centres of species distribution, it is reasonable to conclude that they have also been centres for dispersing these endemics into the neighbouring districts, and that they have, to a less extent, received species from the neighbouring districts. In the Balkan Peninsula as a whole it is chiefly those genera with centres in the Mediterranean Region which show the greatest autochthonous development. The effect of geographical isolation is most clearly illustrated by Crete, and stress need not be laid on the figures at present obtainable for the Aegean islands because of their very incomplete botanical exploration, their relatively small area, and the drastic and wholesale changes in their flora wrought by man. The figures for North Bulgaria are so high because the Stara Planina is included in it. The Danubian Plain of Bulgaria has very few district and not many Balkan Peninsular endemics, though *Verbascum luteo-viride* Turrill is a noteworthy exception. The northern districts agree with the general principle of isolation just indicated, if the facts regarding North Bulgaria are given due weight. Species originating in the northern parts of the Peninsula were able, so far as geographic conditions were concerned, to penetrate northwards after the drying up or draining of the lakes of the Pontic period, though the Ice Age was a limiting factor. They were also geographically able to penetrate southwards. Hence we find relatively few endemics limited to the more northern districts, and those that are so limited are with few exceptions very clearly either relicts of a former wider distribution and are dying out, or are microspecies of very recent origin. The figures as a whole can be favourably interpreted on Willis's Age and Area hypothesis, when this is combined with the geological history and the geographical and meteorological facts.

It might be thought from the examination of a map of the Balkan Peninsula that this area, and especially the district of Greece, forms a floristic cul-de-sac, comparable on a much smaller scale to South Africa and South America. That is, that species in considerable numbers have migrated from the north and have accumulated with further development in an area beyond which they cannot extend. Neither a study of the whole flora nor of the endemics supports the view that such a process has taken place on a large scale in the Balkan Peninsula. Most emphatically the important factors in the origin of the existing flora are first the wide spreading of the Tertiary ancestors, secondly species development within the Peninsula, and thirdly the incoming of new types from the east. The only important immigration from the north is that of the Alpine high mountain species of the north-west and centre, and these can scarcely be said to have found a cul-de-sac in the geographical sense, for, with very limited exceptions, they have not spread into the southern mountains.

SPECIES ENDEMIC TO THE BALKAN PENINSULA

(The number of such for each family in parenthesis after the family name.)

	1. *Crete*	2. *Greece*	2a. *Cyclades*	3. *Thessaly*	4. *Epirus*	4a. *Corfu*	5. *Albania*	6. *N. Maced.*	6a. *S. Maced.*	6b. *Athos*	7. *Thrace*	7a. *Thrac. Is.*	8. *N. Bulg.*	8a. *S. Bulg.*	8b. *Rodope*	9. *Dobruja*	10. *Serbia*	10a. *Novi Pazar*	11. *Montenegro*	12. *Bosnia.*	13. *Herceg.*	14. *Dalmatia*	15. *S. Croatia*	16. *Istria*
Pinaceae (3)	..	1	..	1	1	..	..	2	1	1	..	..	1	..	1	..	2	..	2	1	..	..	..	..
Gramineae (33)	3	9	..	7	3	1	8	6	3	1	1	..	7	2	7	..	3	1	7	3	2	4	1	2
Cyperaceae (2)	..	..	..	..	..	..	..	..	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..
Araceae (4)	1	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	1	1	..	..
Liliaceae (93)	14	40	16	11	5	3	6	10	5	2	6	..	8	8	9	1	3	..	4	4	6	6	4	2
Amaryllidaceae (3)	..	1	..	..	1	..	..	1	..	..	1	..	1	1	1	1	..	..	..	..	..	..	..	..
Dioscoreaceae (1)	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Iridaceae (15)	1	8	4	1	2	1	2	2	2	..	2	..	2	2	1	..	..	..	3	..	3	3	..	..
Orchidaceae (13)	7	3	..	..	..	1	..	..	1	..	..	..	..	..	..	..	2	..	..	1	..	1	..	1
Santalaceae (3)	..	..	..	..	..	..	1	..	..	..	..	..	2	1	..	..	..	..	1	..	1	..	..	..
Aristolochiaceae (5)	2	1	..	..	..	..	..	1	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..
Polygonaceae (3)	1	2	1	..	..	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Chenopodiaceae (1)	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Caryophyllaceae (175)	19	74	9	40	23	3	38	42	32	6	13	6	31	14	33	4	18	1	21	19	22	12	8	2
Ranunculaceae (37)	2	10	2	4	..	1	8	3	4	1	2	..	4	1	5	..	6	..	5	5	5	3	3	..
Papaveraceae (10)	1	4	..	..	1	..	2	1	..	..	1	..	1	1	..	..	1	1	2	..	2	1	1	..
Capparidaceae (1)	..	..	..	..	..	..	..	..	1	1	1	..	..	1	1	..	..	..	..	..	..	..	..	..
Cruciferae (94)	12	4	35	25	15	3	24	27	15	6	6	..	11	8	14	..	10	..	16	9	10	10	8	3
Resedaceae (1)	..	1	..	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Crassulaceae (16)	4	2	1	1	..	..	2	4	1	..	..	..	4	1	6	..	..	..	1	..	..	..	..	..
Saxifragaceae (9)	1	5	1	3	2	1	3	4	2	1	..	..	..	..	7	..	2	..	4	1	1	..	..	..
Rosaceae (24)	1	8	..	7	1	..	5	3	2	..	1	..	2	2	6	..	3	..	3	3	4	1	1	1
Leguminosae (106)	10	38	9	20	14	3	17	29	15	4	17	1	19	11	24	..	11	..	14	8	8	12	6	4

	1. *Crete*	2. *Greece*	2a. *Cyclades*	3. *Thessaly*	4. *Epirus*	4a. *Corfu*	5. *Albania*	6. *N. Maced.*	6a. *S. Maced.*	6b. *Athos*	7. *Thrace*	7a. *Thrac. Is.*	8. *N. Bulg.*	8a. *S. Bulg.*	8b. *Rodope*	9. *Dobrija*	10. *Serbia*	10a. *Novi Pazar*	11. *Montenegro*	12. *Bosnia*	13. *Herceg.*	14. *Dalmatia*	15. *S. Croatia*	16. *Istria*
Geraniaceae (5)	..	4	..	1	1	..	2	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Linaceae (14)	2	9	..	4	3	..	4	1	..	..	..	..	1	2	1	..	..	..	..	..	..	..	..	..
Rutaceae (5)	1	1	..	1	1	..	2	2	2	..	..	..	..	..	1	..	1	..	..	..	..	..	..	..
Polygalaceae (4)	..	2	..	..	..	..	1	1	1	..	1	..	..	1	1	..	..	..	..	..	..	..	..	..
Euphorbiaceae (20)	1	7	1	5	1	..	2	2	3	2	3	1	1	3	2	..	4	..	6	6	6	3	1	1
Celastraceae (1)	..	..	..	..	..	..	..	1	1	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..
Aceraceae (2)	..	1	..	..	..	..	..	..	1	..	..	..	1	..	..	..	1	..	1	2	1	..	..	..
Rhamnaceae (7)	1	4	..	1	..	..	4	2	3	1	..	..	..	1	2	..	..	..	1	1	1	1	1	..
Malvaceae (2)	..	..	..	..	..	..	..	1	1	..	1	..	..	1	1	..	..	..	..	..	..	..	..	..
Hypericaceae (23)	3	7	1	2	2	..	4	4	3	3	6	1	5	5	3	..	2	..	..	..	..	..	..	..
Tamaricaceae (1)	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cistaceae (2)	1	1	1	1	..	..	1	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Violaceae (33)	4	5	..	2	2	..	7	10	6	2	..	..	1	..	6	..	1	..	6	4	2	2	2	2
Thymelaeaceae (1)	..	1	..	..	..	..	..	..	1	1	..	..	..	..	1	..	..	..	..	..	1	..	..	..
Umbelliferae (107)	9	37	7	22	15	5	24	17	16	3	10	..	22	17	24	2	18	3	18	13	8	13	8	3
Primulaceae (12)	4	4	..	2	..	..	2	1	1	1	..	..	2	..	2	..	1	..	1	1	1	1	1	..
Plumbaginaceae (13)	..	3	2	2	..	..	1	3	2	1	1	..	1	2	..	..	1	..	..	1	2	5	2	1
Oleaceae (2)	..	..	..	..	..	..	1	..	..	..	..	..	1	1	..	1	..	1	..	..	..	..	..	..
Gentianaceae (4)	..	..	..	..	..	..	2	..	..	..	2	..	1	..	..	..	..	..	1	1	1	1	1	..
Apocynaceae (1)	..	..	..	..	..	..	..	1	1	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..
Asclepiadaceae (5)	..	1	..	1	..	..	3	1	1	1	1	..	1	..	2	1	..	..	3	..	3	3	..	1
Convolvulaceae (3)	..	2	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..
Borraginaceae (47)	6	16	1	5	5	1	8	10	10	..	8	..	4	9	9	1	3	..	6	5	4	5	2	1
Verbenaceae (1)	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..

Labiatae (152) . .	19	51	5	25	14	3	22	27	23	3	9	1	18	15	25	..	17	..	4	6	10	10	4	4
Scrophulariaceae (126).	6	29	4	27	5	2	16	25	22	3	10	1	24	12	18	4	11	..	19	13	13	6	3	3
Orobanchaceae (4) .	..	..	..	..	..	..	..	..	3	..	..	..	2	..	2	..	3	..	1	1	1	..	..	..
Gesneriaceae (5) .	..	..	..	1	1	..	1	2	..	..	..	..	..	..	..	..	3	..	..	..	..	..	..	..
Lentibulariaceae (1) .	..	..	..	..	..	..	..	..	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..
Globulariaceae (1) .	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Plantaginaceae (2) .	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	1	1	1	1	1	1
Rubiaceae (52) . .	12	25	2	10	6	2	10	5	3	4	1	..	1	2	3	..	..	..	7	1	4	2	2	1
Caprifoliaceae (2) .	..	1	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	1	..	1	1	..	..
Valerianaceae (7). .	1	4	..	1	..	..	3	..	..	1	..	..	..	1	..	..	1	..	2	..	1	..	..	..
Dipsacaceae (32). .	2	8	..	6	3	1	13	4	5	4	4	..	8	5	7	..	10	..	6	5	7	2	3	..
Campanulaceae (76) .	9	19	8	11	2	2	11	7	4	5	3	2	9	1	13	1	7	..	8	11	6	14	5	5
Compositae (327) .	40	107	23	59	34	2	56	44	36	16	22	3	56	28	45	11	35	2	34	33	31	37	12	10
Totals (1754) . .	201	564	133	310	163	36	318	309	234	74	136	11	255	164	286	27	180	9	210	169	170	160	80	48

SPECIES ENDEMIC TO ONE DISTRICT ONLY OF THE BALKAN PENINSULA

	1. *Crete*	2. *Greece*	2a. *Cyclades*	3. *Thessaly*	4. *Epirus*	4a. *Corfu*	5. *Albania*	6. *N. Maced.*	6a. *S. Maced.*	6b. *Athos*	7. *Thrace*	7a. *Thrac. Is.*	8. *N. Bulg.*	8a. *S. Bulg.*	8b. *Rodope*	9. *Dobruja*	10. *Serbia*	10a. *Novi Pazar*	11. *Montenegro*	12. *Bosnia*	13. *Herceg.*	14. *Dalmatia*	15. *S. Croatia*	16. *Istria*
Gramineae (21)	2	3	..	2	..	..	4	2	..	..	..	..	3	..	..	..	1	..	2	1	..	1	..	..
Cyperaceae (2)	..	..	..	..	..	..	..	..	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..
Araceae (3)	1	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Liliaceae (57)	9	20	8	2	..	1	..	5	..	..	2	..	3	2	3	..	..	..	1	..	..	1	..	..
Amaryllidaceae (2)	..	1	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Dioscoreaceae (1)	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Iridaceae (6)	..	3	..	..	..	..	..	1	..	..	..	..	1	..	..	..	..	..	1	..	..	..	..	..
Orchidaceae (9)	6	1	..	..	..	..	..	..	1	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..
Santalaceae (1)	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..
Aristolochiaceae (5)	2	1	..	..	..	..	..	1	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..
Polygonaceae (1)	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Chenopodiaceae (1)	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Caryophyllaceae (74)	12	26	..	5	2	..	4	6	1	2	1	..	2	..	4	1	..	..	..	2	3	2	..	1
Ranunculaceae (22)	2	5	1	2	..	..	3	..	1	..	1	..	..	..	..	..	1	..	..	2	1	1	2	..
Papaveraceae (6)	1	4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..
Cruciferae (39)	8	12	2	2	..	..	2	3	..	3	1	..	1	..	2	..	..	..	1	1	..	..	1	..
Crassulaceae (9)	2	..	..	..	..	..	1	1	..	..	..	..	2	..	2	..	..	..	1	..	..	..	..	..
Saxifragaceae (3)	..	1	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..	..	..	..	..	..	..
Rosaceae (13)	1	4	..	2	..	..	2	..	..	..	1	..	..	..	1	..	..	..	..	1	..	..	..	1
Leguminosae (48)	5	13	3	1	2	..	2	3	2	..	4	..	6	1	4	..	..	..	1	..	..	1	..	..
Geraniaceae (1)	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Linaceae (9)	2	3	..	1	..	..	..	..	..	..	..	..	..	2	..	..	1	..	..	..	..	..	..	..
Rutaceae (2)	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..
Polygalaceae (3)	..	2	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Euphorbiaceae (8)	..	4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	2	..	..	..	1
Aceraceae (1)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..
Rhamnaceae (2)	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Malvaceae (1)	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..
Hypericaceae (11)	3	3	..	..	..	..	1	1	..	..	1	..	1	..	1	..	..	..	..	..	..	..	..	..
Tamaricaceae (1)	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Violaceae (17)	4	3	..	..	..	..	..	4	1	..	..	..	..	..	..	..	..	..	2	2	..	..	..	1
Umbelliferae (49)	6	17	4	2	..	..	4	2	1	..	..	..	1	2	2	..	2	..	2	2	..	1	1	..
Primulaceae (8)	2	2	..	1	..	..	1	..	..	..	..	..	1	..	1	..	..	..	..	..	..	..	..	..
Plumbaginaceae (9)	..	1	1	1	..	..	1	1	1	1	..	..	..	1	..	..	..	..	..	..	..	1	..	..
Gentianaceae (2)	..	..	..	..	..	..	1	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..
Asclepiadaceae (1)	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..
Convolvulaceae (3)	..	2	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..
Borraginaceae (22)	2	7	..	..	1	..	2	2	..	..	3	..	1	3	1	..	..	..	..	..	..	..	..	..
Verbenaceae (1)	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..
Labiatae (84)	13	26	2	6	2	1	2	4	3	..	2	..	4	4	6	..	3	..	3	1	1	1	..	..
Scrophulariaceae (65)	4	11	1	6	..	..	3	6	4	2	3	1	6	3	2	1	..	..	2	3	4	1	1	1
Orobanchaceae (1)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..
Gesneriaceae (2)	..	..	..	1	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..
Globulariaceae (1)	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Rubiaceae (32)	7	14	1	3	..	..	1	1	..	1	..	..	..	..	1	..	..	..	1	..	1	..	1	..
Valerianaceae (3)	1	1	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..
Dipsacaceae (13)	2	4	..	..	..	..	1	..	..	..	..	..	1	..	1	..	2	..	..	..	..	1	1	..
Campanulaceae (41)	6	9	3	3	..	..	2	2	..	..	2	..	3	..	2	..	1	..	1	1	1	4	..	1
Compositae (185)	26	50	7	11	4	1	6	9	4	7	4	..	17	7	11	3	3	..	2	3	..	9	..	1
Totals (901)	131	260	33	51	12	3	46	54	19	16	30	1	56	28	47	5	7	0	20	22	11	25	7	7

The total number of accepted endemics is thus 1,754, out of a flora consisting of 6,530 species. The families contributing most are: *Compositae* (327), *Caryophyllaceae* (175), *Labiatae* (152), *Scrophulariaceae* (126), *Leguminosae* (107), *Umbelliferae* (107), *Cruciferae* (94), and *Liliaceae* (93). Of the genera the following are the largest contributors of species: *Centaurea* (114), *Dianthus* (64), *Verbascum* (55), *Thymus* (53), *Campanula* (50), *Silene* (46), *Viola* (33), *Astragalus* (31), *Stachys* (30), *Asperula* (27), *Galium* (25), *Trifolium* (23), *Hypericum* (23), *Allium* (22), *Crepis* (21), *Euphorbia* (20), *Achillea* (19), *Alyssum* (18), *Anthemis* (18), *Cirsium* (18), *Senecio* (17), *Colchicum* (16), *Veronica* (16), *Fritillaria* (15), *Linum* (14), *Alectorolophus* (14), *Crocus* (13), *Peucedanum* (13), *Seseli* (13), *Scabiosa* (13), *Muscari* (12), *Ranunculus* (12), *Erysimum* (12), *Genista* (12), *Cerastium* (11), *Minuartia* (11), *Alkanna* (11), *Onosma* (11), *Tulipa* (10), *Cytisus* (10), *Freyera* (10), *Teucrium* (10), and *Knautia* (10).

TYPES OF ENDEMISM.

We must now consider a few taxonomic and phytogeographical data in illustration of the chief types of endemism in our area. The species mentioned follow the sequence of families in the classification of Engler and Prantl.

Abies cephalonica Loud. is in the main vicarious with *A. alba* Mill. within the Balkan Peninsula. It may also be considered geographically vicarious with *A. nordmanniana* Spach, a species ranging from north-west Asia Minor to the Caucasus. Where *A. cephalonica* and *A. alba* meet 'intermediates' are found, or at least individuals occur showing various combinations of the characters of the two species, as in the Athos Peninsula and Thessaly. It is even possible that in the Athos Peninsula, and perhaps elsewhere in the south-eastern parts of the Balkan Peninsula, *A. nordmanniana* is also involved. *A. cephalonica* occurs in a number of varieties which have sometimes been considered as species (see *Bot. Mag.* t. 8691). It is recorded for districts 2, 3, 4, 6, 6a, 6b, but only just reaches over the boundary into North Macedonia (6) between Lakes Prespa and Okhrida. *Picea omorika* Willk. and *Pinus peuce* Griseb. are certainly Tertiary relicts, and are dealt with under that heading.

Brachypodium sanctum Janka, limited to districts 3, 6a, 6b, 8b, is probably a relatively old type, being morphologically very distinct from other species of the genus. *B. tenerum* Vel. is morphologically very close to *B. pinnatum* L. of which it may be only a variety, or a recently segregated species. A number of microspecies of the *Bromus erectus* group occur in the Balkan Peninsula, and several of them are endemics presumably recent in origin. *Dactylis rigida* Boiss. et Heldr.,

limited to Crete, is altitudinally vicarious with *D. glomerata* L. *Poa timoleontis* Heldr. is limited to 2, 2a, 3, 4, 5, 6, 6a, 7, 8, 8a, 8b, so far as I know, though there is a very doubtful record of the species occurring near Damascus. *Sesleria dorfleri* Hayek, limited to Crete, has a Caucasian taxonomic affinity. *Trisetum laconicum* Boiss. et Orph. is limited to Mt. Malevo in the Morea. It is geographically and altitu-

dinally vicarious with the more northern *T. flavescens* Pal. de Beauv. *Heleocharis boissieri* Podp. is, at most, a microspecies from South Bulgaria, closely allied taxonomically to *H. palustris* R. Br. *Arum creticum* Boiss. et Heldr. is allied to *A. orientale* Bieb. and is pseudovicarious with it.

The *Liliaceae* have the greatest number of endemics of all the monocotyledonous families and *Allium* has more than any other monocotyledonous genus. Taxonomically the species of *Allium* show very varied degrees of affinity with their nearest allies. Thus *A. callimischon* Link, *A. chamaespathum* Boiss., *A. heldreichii* Boiss., and *A. phthioticum* Boiss. et Heldr. are very distinct species; *A. confusum* Hal., *A.*

gomphrenoides Boiss., and *A. rhodopeum* Vel. are 'small' species with close allies in the Balkan Peninsula. *A. circinnatum* Sieber, *A. frigidum* Boiss. et Heldr., *A. luteolum* Hal., *A. meteoricum* Heldr. et Hausskn., and *A. rubrovittatum* Boiss. et Heldr. are vicarious or pseudovicarious with their nearest allied species. *Chionodoxa cretica* Boiss. et Heldr. and *C. nana* Boiss., both endemic to Crete, are altitudinally vicarious with each other. The 16 endemic species of *Colchicum* and the 15 of *Fritillaria* show in their detailed taxonomy and geographical distribution some indications of hamagenesis.[1] *Merendera attica* Boiss., limited to 2, 8, 8a, 8b, is most closely related to *M. caucasica* Bieb. and may be only a variety of this species. The genus *Muscari* contains 12 species endemic to our area and many of these are microspecies. *Narthecium scardicum* Košanin is very closely related to *N. balansae* Briq. (*N. caucasicum* Mischenko), endemic to the Caucasus. The endemic species of *Ornithogalum* are mostly from Macedonia and Bulgaria. There is a decided preponderance of the endemics of this family in the Mediterranean domain of the Balkan Peninsula and especially in Crete, Greece, and the Cyclades.

A few especially interesting species and genera of the remaining families of Monocotyledons may be mentioned. *Galanthus maximus* Vel. is limited to 6, 7, 8, 8a, 8b, 10, and *G. reginae-olgae* Orph. to 2. *Dioscorea balcanica* Košanin is known only from northern Albania and is allied to *D. caucasica* Lipsky endemic to the Caucasus. There are 13 endemic species of *Crocus*, some of which, as *C. boryi* Gay and *C. veluchensis* Herb., have a fairly wide distribution in the Balkan Peninsula, while 4 are known from only one district each. *Iris urumovii* Vel., from North Bulgaria, is the only endemic iris. The genus *Ophrys* shows the greatest development of microspecies of all the *Orchidaceae* of our flora, especially in Crete and Greece.

The *Caryophyllaceae* with 175 endemic species have more than any other family except the *Compositae*, while the genus *Dianthus* with 64 endemic species, out of a total of 101, takes second place to *Centaurea* in this respect. We again find all degrees of taxonomic distinctness and all sizes of distributional area amongst the endemic species of *Dianthus*. On the whole, however, the taxonomic and phytogeographical evidence is in favour of a recent origin of many of the species, and this by means of hybridization. Thus amongst the large number of microspecies of the *Carthusianorum* group of *Dianthus* the same characters appear again and again but in varying combinations. In *Minuartia* they appear to be either mutational segregates or examples of divergent hamagenesis. The genus *Silene* with 46 endemics, many of which are taxonomically very distinct, has, like *Dianthus*, an

[1] See p. 361.

important centre of development and distribution within the Balkan Peninsula. The range of habitats, on the whole, is greater than for *Dianthus*.

The 7 species of *Aconitum* limited to the Balkan Peninsula are, with one exception, all found in the north-western districts. Of the 8 endemic species of *Aquilegia* the most distinct is the beautiful *A. aurea*

Janka, limited to 6, 8, 8b. *Caltha longirostris* Beck is a microspecies limited to 12. *Helleborus cyclophyllus* Boiss. is taxonomically a quite distinct species with a wide distribution through 2, 3, 4a, 5, 6, 6a, 6b, 8b. It is often abundant within its area. Several of the species of *Ranunculus* are taxonomically very distinct, as for example, *R. cupreus* Boiss. et Heldr. and *R. incomparabilis* Janka. The genus *Corydalis* shows a greater degree of development than is indicated by the 5 endemic species because the microspecies separated by Velenovský and Adamović have been considered only as varieties of *C. solida* Sw. *Cleome aurea* Čelak., from 6a, 6b, 7. 8a, 8b, is certainly a relict endemic.

To the 94 endemic *Cruciferae* the genus *Alyssum* contributes 18 species, most of which might on taxonomic and phytogeographical grounds be considered as of recent origin. The same is true of the endemic species of *Arabis*, *Aubrietia*, *Barbarea*, and *Brassica*. *Crenularia orbiculata* Boiss., from Greece and Athos, is probably fairly old, and *Degenia velebitica* Hayek may be a relict species. *Erysimum* is especially developed in Crete and Greece but several of the endemic species have a fairly wide distribution. *Fibigia lunarioides* S. et S. from the Cyclades and *F. triquetra* Boiss. from Dalmatia and South Croatia are distinct and probably fairly old species. The monotypic genus *Lepidotrichum* is endemic to our area in 7, 8, 8a. Around Varna I have seen it in abundance. *Peltaria emarginata* Hausskn. and the three species of *Ptilotrichum* are probably all fairly old, while *Ricotia cretica* Boiss. et Heldr. is an old, if not a relict, species. The endemic species of *Sedum* and *Sempervivum* appear to be in part fairly old and in part recent or fairly recent as species. Neither *Rosa* nor *Rubus* is represented by such a mass of hybrids and microspecies as in Central Europe. *Sibiraea croatica* Degen is certainly a relict species.

The *Leguminosae*, the second largest family in total species of our flora, have 107 endemics, fewer than might be expected. *Alhagi graecorum* Boiss. is probably fairly old. The microspecies of *Anthyllis* have been mostly considered as varieties of *A. vulneraria* L. or *A. dillenii* Schult., though till more field-work and breeding experiments have been done this is quite tentative. *Argyrolobium dalmaticum* Aschers. et Graebn. from Dalmatia and *A. sessilifolium* Janka from Bulgaria are both at least fairly old. The 31 endemic species of *Astragalus* out of a total number of 72 are exceptionally interesting from the present standpoint. Their distribution is summarized elsewhere (p. 471) and it will suffice to mention a few here by name. *Astragalus agraniotii* Orph. is probably fairly old but is limited to Greece. *A. apollineus* Boiss. et Heldr. and *A. sericophyllus* Griseb, *A. creticus* Lam. and *A. rumelicus* Bunge, and *A. drupaceus* Orph. and *A. graecus* Boiss. et Orph. are pairs of endemic vicarious or pseudovicarious species. *A. haarbachii* Sprun., *A. idaeus* Bunge, *A. illyricus* Bernh., and *A. nummularius* DC. certainly appear on taxonomic grounds to be fairly old species. *A. physocalyx* Fisch. is an old species formerly only known from Plovdiv and now extinct except in cultivation at Sofia and Vranya. *A. argolicus* Hausskn., *A. fialae* Degen, *A. macedonicus* Heldr. et Charr., *A. skorpilii* Vel., *A. sofianus* Vel., and *A. vandasii* Vel. may be recent or fairly recent microspecies. The majority of the endemic species of *Cytisus* are probably of recent origin and have resulted from segregation of hybrids, but many of the endemic species of *Genista* are taxonomically more distinct. *Petteria ramentacea* Presl

is at least an old species. The genus *Trifolium*, with 23 endemics, is represented by a few probably fairly old species and a greater number which appear to be of recent or fairly recent origin.

Most of the endemic species of *Linum* are apparently microspecies presumably of recent origin. Those of the *flavum* group appear to have originated by a combination of hamagenetic modification and hybridization. The genus *Euphorbia* has 20 endemic species in the Balkan Peninsula and these show very varying areas of distribution. *Acer heldreichii* Orph. extends to 2, 6a, 8, 10, 11, 12, 13. *Paliurus microcarpus* Wilmott may prove to be only a variety of *P. spina-Christi* Mill., limited, so far as is known, to South Macedonia. The 23 endemic species of *Hypericum* are distributed chiefly in the southern and east-central parts of the Balkan Peninsula, and 11 of them are found in only one area each. Many of the 33 endemic species of *Viola* are microspecies of very limited distribution. Hybridization has been an important factor in the differentiation found within this genus. There are, however, a few species which are morphologically very distinct and may represent old or fairly old types. Examples are *V. cretica* Boiss. et Heldr., *V. delphinantha* Boiss., and *V. fragrans* Sieb. *Daphne jasminea* S. et S. is probably fairly old judging from its taxonomy and distribution.

The *Umbelliferae* are represented in our flora by 107 endemics divided amongst 31 genera. *Peucedanum* and *Seseli* each with 13 and *Freyera* with 10, contain the largest number of endemic species. There is thus no genus which accounts for an exceptionally large number such as *Dianthus* and *Silene* in *Caryophyllaceae*, *Verbascum* in *Scrophulariaceae*, or *Centaurea* in *Compositae*. Many of the genera of *Umbelliferae* are acknowledged to be artificial, at least relative to the genera of many other families, and the species are often difficult to discriminate. The family is usually regarded as one of the most highly evolved of the *Polypetalae* and on taxonomic and phytogeographical grounds it may be accepted that in the Balkan Peninsular flora many of the endemic species are of recent origin, often through fractional mutation. Within their own genera (or tribes) the following are probably old or fairly old: *Bupleurum apiculatum* Friv., *B. flavicans* Boiss. et Heldr., *Carum meoides* Hal., *Chaerophyllum creticum* Boiss. et Heldr., *Eryngium ternatum* Poir., *Ferulago monticola* Boiss. et Heldr., *F. nodosa* Boiss., *F. balcanica* Hal., *Oenanthe incrassans* Bory et Chaub., *Peucedanum creticum* Sieber, *Portenschlagia ramosissima* Vis., and *Sclerochorton junceum* Boiss.

Androsace hedraeantha Griseb., limited to 5, 6, 8, 8b, 10, 11, is the only endemic *Androsace*. Two species of *Cyclamen* are known only from Crete and two only from Greece, while *C. graecum* Link is

recorded from 1, 2, 3, 6a, 6b. *Lysimachia anagalloides* Sm. from Crete and Greece is possibly fairly old.

Primula deorum Vel., a very beautiful and distinct species, is known only from the Rila (8b) and *P. frondosa* Janka only from North Bulgaria (8). *P. kitaibeliana* Schott, a less distinct species, is known from 12, 13, 14, 15. Two species of *Soldanella*, from Albania and the Pindus respectively, are microspecies of probably recent origin. The 13 endemic species of the *Plumbaginaceae* are, with two possible exceptions, microspecies of limited distribution with the evidence pointing to their being of recent origin. *Forsythia europaea* Degen et Baldacci is a relict type, and *Fraxinus pallisae* Wilmott is quite a distinct species of ash from the Black Sea districts of 8, 8a, 9. *Gentiana crispata* Vis. is probably fairly old. The 5 endemic species of *Vincetoxicum* are all microspecies and *Convolvulus mairei* Hal. and *C. radicosus* Heldr. et Sart. may both prove to be either mere fluctuating habitat forms or else fixed ecotypes, when cultural experiments can be conducted with them.

The *Borraginaceae* of the Balkan Peninsula would well repay detailed study from the standpoint of species formation, but this would have to be on the threefold basis of herbarium, field, and breeding work. My studies on this family up to the present have been almost limited to the two former, and the following suggestions are therefore tentative. *Alkanna*, with 11 endemics limited to the south and central parts of our area, shows the influence of geographical isolation in species formation. In *Anchusa* my field studies have suggested for the *officinalis* group, the importance of hybridization in causing diversity. *Cerinthe retorta* S. et S., *Halacsya sendtneri* Dörfl., and *Moltkia petraea* Griseb. are probably old or even relict species. The species of *Onosma*, at least in part, suggest hamagenesis and fractionization as methods of their species formation. *Pulmonaria auriculata* Hal., *Solenanthus albanicus* Degen et Baldacci, and *S. scardicus* Bornm. are probably at least fairly old. The latter genus may have segregated its species in a hamagenetic manner.

The *Labiatae*, with 152 endemic species, form one of the characteristic families of the Balkan Peninsular flora and vegetation, especially in the summer. The endemics are divided amongst 19 genera (accepting the division of *Origanum* and *Satureia* each into 3 genera). Most of the endemic species have close affinities within our area, many are xeromorphic in structure, and the family is especially represented in the macchie and phrygana of the Mediterranean domain and on dry hill slopes in both the Mediterranean and Central European domains. Since the macchie, in part, and the phrygana and dry hill slopes almost entirely owe their origin as such to the activities of man, it is a fair

conclusion that man's destructive and modifying influences have resulted in an increase in the distribution of the genera and species and in the possibilities of survival of new species. This conclusion agrees with the taxonomic and phytogeographical facts. A considerable number of the species are microspecies, conforming to all the criteria for quite recently formed species. Hybridization and consequent segregation, mutation (especially fractional, and possibly sometimes of a hamagenetic type), and natural selection would all appear to have played a part. It must be remembered that we are dealing here with the species as the unit, and the above statement is not controverted by the fact (now established palaeontologically) that some at least of the family and generic characters and even their combinations are geologically old, as indeed they are for many, probably a majority, of the Angiosperm families. The following, within their genus, are probably old or fairly old: *Calamintha suaveolens* Boiss., *Nepeta melissaefolia* Lam., *N. scordotis* L., *Phlomis cretica* Presl, *Salvia calycina* S. et S., *S. jurisicii* Košanin, *S. pomifera* L., *Scutellaria rupestris* Boiss. et Heldr., *Sideritis theezans* Boiss. et Heldr., *Stachys spinosa* L., and *Teucrium aroanium* Orph. The genus *Thymus* has presented considerable difficulties. Its taxonomy is in an unsatisfactory state, and though a monograph is in preparation I doubt if the real relationships of the numerous 'microspecies' will be properly established before extensive breeding work is combined with field and herbarium studies. From extensive examination and collecting in the Balkan Peninsula I am convinced that hybridization has played an important part in the production of the numerous character-combinations occurring in different individuals of this genus. Especially in Bulgaria has this seemed evident and notably in the Rodope massif.

The *Scrophulariaceae* with 126 endemic species, of which 55 are species of *Verbascum*, have probably, like the last family, increased their importance in the flora and vegetation of the Balkan Peninsula since the destruction of forests by man. *Alectorolophus*, with 14 endemic microspecies of limited distributions, appears to be a genus where fractionization has largely occurred, with or without extensive hybridization. The species of *Celsia* show some degree of vicarism, perhaps a result of hamagenesis. *Digitalis leucophaea* Sibth. and *D. viridiflora* Lindl. are both distinct species. Three of the four endemic species of *Linaria* are microspecies taxonomically, but *L. peloponnesiaca* Mill. is considered fairly old. The endemic species of *Melampyrum* and *Pedicularis* are probably recent. The genus *Verbascum* is widespread throughout the Balkan Peninsula—especially in the central parts. The distribution of the 55 endemic species is as follows: 1/1 2/10 2a/3 3/13 4/2 5/3 6/11 6a/13 6b/1 7/6 8/10 8a/6 8b/8 9/3 10/3

11/8 12/3 13/1 14/1. A majority of the endemics thus occur in Thessaly and Macedonia. The one endemic species occurring in Crete is *V. spinosum* L., the only known member of the section *Spinosa*. The two other (non-endemic) species known from Crete are *V. macrurum* Ten. (distribution 1, 2, 3, 11, 14, 16) and *V. sinuatum* L. (1, 2, 2a, 3, 4, 4a, 5, 6, 6a, 7, 8, 8a, 8b, 11, 14, 16). It is probable that these are relatively old and it follows that the development of the considerable number of endemic species on the mainland may have occurred after the separation of Crete as an island. Moreover field studies and preliminary cultural experiments have convinced me that hybridization commonly occurs in this genus in nature. Thus I have had wild seed from near Varna, and also from Istria, segregating at Kew several distinct types, and on examining the locality plants with the various characters of the segregates were found. In 1918 I commented on the mulleins as a characteristic feature of the hill vegetation of South Macedonia, and it seems very probable that here is a genus which has enlarged its species number and the distributional areas of the species very considerably since the destruction of forests by human activity. The Cyclades have 8 species, of which 3 are endemic, compared with the 18 of mainland Greece, of which 10 are endemic. The genus *Veronica* with 16 endemics is widely distributed in our area in a great diversity of habitats. *V. euxina* Turrill is only known from the hills to the south of Varna, where it occurs amongst the shiblyak. It grows mixed with *V. orchidea* Crantz, its nearest morphological affinity, from which it is, however, quite distinct, and I could find no intermediates. Its characters are retained under cultivation. *V. rigida* Turrill, which I collected in South Macedonia, has also retained its characters under cultivation, now for 8 years. *V. turrilliana* Stoy. et Stef. was described from the Strandja in eastern Bulgaria, and the authors suggest that it is a descendant of *V. prostrata* L., having been derived from this species in an older epoch through the agency of the habitat conditions, and that it is not a recently formed ecological race. *Wulfenia baldaccii* Degen, *Lathraea rhodopea* Dingler, and the Balkan Peninsular species of *Gesneriaceae* are all relicts and are dealt with under that heading.

A monograph of the genus *Asperula* is now in preparation and it has already become evident that the Aegean area is one of the most important centres of distribution for the species of this genus. Twenty-seven species endemic to the Balkan Peninsula are at present recognized, though we may make some slight modifications when additional material has been examined. These are especially concentrated in the southern parts of the Peninsula. *Galium* with 25 endemic species is morphologically closely related to *Asperula* and is probably polyphyletic in

origin. The genus *Knautia* shows a rather diversified development in the Balkan Peninsula, but the endemics are mostly microspecies, while many of the 13 endemic species of *Scabiosa* are taxonomically more distinct, and a few, such as *S. sphaciotica* Roem. et Schult., may be old.

Asyneuma with 7 endemics is, relative to the Balkan Peninsula, of eastern origin. *Campanula* with 50 endemic species contributes the fifth largest number to the total for our area. Many of the species are surely recent, and it may be that hybridization is an important cause of species formation in the genus. On taxonomic and phytogeographic grounds the following are considered old or fairly old species or types: *C. anchusiflora* S. et S., *C. celsii* DC., *C. cephallenica* Feer, *C. heterophylla* L., *C. laciniata* L., *C. reiseri* Hal., *C. rupestris* S. et S., *C. sartorii* Boiss. et Heldr., *C. sibthorpiana* S. et S., and *C. spruneriana* Hampe. *Diosphaera rumeliana* Bornm. and *D. jacquinii* Buser are old, while *D. asperuloides* Buser and *D. chalcidica* Buser may be younger. The genus *Hedraeanthus* has the chief centre of distribution in the north-west of the Balkan Peninsula. Its most widely distributed species is *H. graminifolius* DC. which extends to Italy, Sicily, and Transylvania. The remaining 7 species are all endemic to our area and for the most part occur within the distribution of *H. graminifolius*. Taxonomically there is nothing against their having been derived from this species, and the genus, on this basis, is the best example of the working of the Age and Area theory of Dr. Willis which I know in the Balkan Peninsular flora. *Jasione bulgarica* Stoy. et Stef. is a very distinct species limited to the Rila mountains and Pirin. *Petromarula pinnata* DC. is a relict, *Symphyandra cretica* A. DC. is old, and *S. hofmannii* Pant. and *S. sporadum* Hal. are doubtful in age as species.

The *Compositae* are both the largest family and that containing the greatest number of endemics (327) in the Balkan Peninsular flora. *Achillea*, with 19 endemic species, is widely spread, but is especially characteristic of the Mediterranean domain. It occurs at all altitudes, and very probably altitudinal isolation of ecotypes has been an important feature of its specific evolution. The genus *Ammanthus* is considered elsewhere (p. 447). *Amphoricarpus neumayeri* Vis. is a relict type. *Anthemis* is largely a Mediterranean genus in the Balkan Peninsular flora and most of its endemics are limited to the Mediterranean domain or to Bulgaria. Mention may be made of the very fine *A. sancti-johannis* Stoy., Stef., et Turrill from the Rila, a species of the *A. tinctoria* group but quite distinct. *Bellidium minutum* L. from 1, 2, 2a is probably old. The thistles are well represented by endemic species of *Carduus*, *Carlina*, *Carthamus*, *Cirsium*, and *Onopordon*, many of which are morphologically very distinct. *Centaurea* has more endemic species (114) than any other genus in our flora. It is probable

that its history, in part, is similar to that of *Verbascum*. Contributions have been received from the east, especially from Asia Minor, but the Balkan Peninsula itself is a very important centre of species formation and distribution. That hybridization is a factor in causing the specific and varietal diversity is certain, though mutation is probably another. Seed from near Varna of *Centaurea diffusa* Lam. grown in the Herbarium Experimental Ground at Kew gave rise to a dozen different types of plants, and I found a corresponding diversity amongst the wild plants near Varna. While many of the species of *Centaurea* are judged on taxonomic and phytogeographic grounds to be of recent origin the following are probably old or fairly old within their own affinity: *C. amplifolia* Boiss. et Heldr., *C. argentea* L., *C. baldaccii* Degen, *C. graeca* Griseb., *C. grisebachii* Nyman, *C. guicciardii* Boiss., *C. lancifolia* Sieber, *C. minoa* Heldr., *C. mixta* DC., *C. psilacantha* Boiss. et Heldr., *C. raphanina* S. et S., and *C. sublanata* Boiss. Seventy-one of the endemics occur each in only one district. The 21 endemics of *Crepis* are mainly limited to the Mediterranean domain. *Echinops albidus* Boiss. and *E. graecus* Mill. are probably the oldest of the six endemic species of *Echinops*. The genus *Hieracium* shows a diversity second only to that occurring in Central and northern Europe. Since the microspecies of *Hieracium* reproduce by apogamy or parthenogenesis I consider they require separate taxonomic treatment, and in this work only the primary species in the sense of Zahn are included. On this basis only 4 endemics are accepted, and these are probably all relatively old. *Inula* with 6 endemic species is especially well represented in the Mediterranean domain. *Jurinea* with 9 endemic species is widely scattered in the Peninsula, but their individuals are rarely abundant. *Scorzonera* with 6 endemics is especially Mediterranean. *Senecio* has 17 endemic species in our area, and these occur mainly in the southern districts and in Bulgaria.

ANALYSIS OF THE ENDEMIC CATEGORY.

An analysis of the endemic category, containing 1,754 species, has been made by the methods used in studying the flora as a whole, and the data obtained will now be considered.

Duration and Life-form. The totals under the different classes are:

B. ħ/7 ħ/71 ɥ/1340 ②/174 ①/191.
C. MM/5 M/11 N/7 Ch/448 H/957 G/165 HH/7 Th/191.
D. 1/3 2/4 3/4 4/48 5/8 6/2 7/78 9/257 10/34 12/239 13/5 14/70 15/2 16/837 17/164 18/191 19/2 20/39.

The first most striking feature of the figures is the overwhelming dominance of perennial herbs and the corresponding low numbers of

woody plants and annuals. Expressed as percentages of the corresponding categories of the whole flora the figures for duration have the following values:

ħ/6·1 ħ/16 ɥ/32 ②/36·2 ①/12·8.

While nearly one-third of the perennial herbs and over one-third of the biennials are endemic, only just over one-eighth of the annual species, less than one-sixteenth of the trees and one-sixth of the shrubs, of the Balkan Peninsular flora, are limited to this area. In Raunkiaer's system the hemicryptophytes and therophytes are the dominant categories for the whole flora, but the position of the latter is taken by the chamaephytes when the endemics alone are considered. The proportion of endemics to the total species in each of these categories is Ch/42·1 H/30·8 Th/12·8. The helo-hydrophytes number only 7 endemics out of 195, of which only 2 out of 70 are true aquatic plants. This agrees with the generalization made elsewhere that the species of this category are mostly widely distributed. The figures obtained cannot be reconciled with the view that woody plants are older than herbaceous, amongst which the annual habit is the most recent, and at the same time with the view that area occupied indicates relative age.

Habitats. The figures for the endemic species alone are as follows: 2/1 3/41 4/3 5/131 6/172 7/359 8/51 9/547 10/26 11/521 12/8 13/42 14/24 15/9 16/21. The habitats of 187 of the endemics are unknown to me. It is obvious that the three types of habitat, dry stony ground, rocky places, and grassy places, provide for a very great majority of the endemic species. Woods and brushwoods have respectively 131 and 172 endemics.

Altitudinal zonation. The figures for the endemics are: 1/60 2/343 3/768 4/670 5a/333 5b/405 5c/204. The altitudinal limits of 65 endemic species are unknown to me. Although most occur in the hill and montane zones the endemic species are fairly well distributed in altitude from the lowlands to the highest mountain zone. Expressed as percentages of the total numbers of species occurring in the respective zones the following figures are obtained: 1/15·8 2/12·8 3/19·9 4/23·9 5a/25·4 5b/33·9 5c/38·5. Thus the proportion of the endemics to the whole flora of any altitudinal zone increases for each successive upward move from the lowlands to the highest mountain zone. This is in accordance with the view to which all my relevant research has led me that many of the species of the high mountain flora of the Balkan Peninsula, and especially of the southern parts, have originated in our area, in this sense *in situ*. Most of the high mountain endemics have taxonomic affinities with lowland or hill species, but there are a few relict species, or types, in the highest mountain zones.

Flowering period. The numbers of endemics flowering in each month are: 1/3 2/18 3/73 4/226 5/513 6/766 7/889 8/480 9/72 10/25 11/21 12/6. The flowering times of 198 endemic species are unknown to me. July is the month with most endemic species in flower in the Balkan Peninsula, while June has slightly the higher figure for the whole flora.

Distribution within the Balkan Peninsula. The total figures and those for each family are given in the tables in this chapter, to which reference should be made. It should be noted that for some areas, especially for Epirus (4), the Thracian islands (7a), and Novi Pazar (10a), the number of endemics is probably much lower than it will be when these districts have been fully explored botanically. There are certainly many endemics yet to be discovered in other parts of the Balkan Peninsula, but it is improbable that the figures now obtained will be altered much relative to the different areas, with the above exceptions, unless a different species-standard be accepted. Greece, with 564 Balkan Peninsular endemics, of which 260 are limited to this district, has the richest endemic flora. Albania with 318, of which, however, only 46 are limited to the district, comes next, while Thessaly with 311 and 51 respectively is a close third. For both the Balkan Peninsular and the district endemics there is, in general, an increase from the north-west towards the south, Epirus and Corfu being exceptions.

There is no known test for the absolute age of a wild species, or for its age in a given district, and historical or palaeontological evidence is almost entirely lacking. To attempt to estimate, even in vague terms, the age of species by taxonomic and phytogeographic data can frequently give only a relative result influenced by subjective factors. I therefore lay no stress on the following figures, for even if they have a larger degree of accuracy than I suppose they are capable of more than one interpretation. Taking the endemics one by one I have classified them, entirely by taxonomic and distributional facts, as follows:

1. Having no near morphological relatives of the genus or section in the Balkan Peninsula or neighbouring countries, i. e. *relicts*. 16 species.
2. Morphologically and geographically isolated types but the genus represented by other species in the Balkan Peninsula or neighbouring countries, i. e. *old species*. 71 species.
3. Morphologically and geographically well differentiated types within a genus well represented in the Balkan Peninsula and often occurring in areas now separated by the sea, i. e. *fairly old species*. 184 species.

4. Morphologically well differentiated species but with the nearest taxonomically similar species also occurring in the Balkan Peninsula or immediately neighbouring countries, i. e. *fairly recent species.* 339 species.
5. Microspecies with their nearest taxonomically related species growing in the same or near-lying areas, i. e. *recent species.* 896 species.
6. Species occupying areas or zones contiguous to, or nearly contiguous to, but separate from the areas or zones occupied by the taxonomically most similar species, i. e. *geographically or altitudinally vicarious species.* 128 species.

The remaining species I am quite unable to place at present. The problem of the vicarious species is beyond the scope of this work, but the phytogeographical evidence agrees with the view that some of them have resulted from a form of hamagenetic evolution or fractional mutation.

It is certain that the vast majority of the endemic species of the whole flora are either morphologically well differentiated species or microspecies of genera with other, usually many, species in the flora of the Balkan Peninsula. That they are of recent or fairly recent origin is a debatable deduction from the taxonomic and phytogeographical facts. Even if they be accepted as such it does not follow that in any taxonomic group the endemics are relatively the most recent species in any geographical district. The doubt indicated is illustrated by the endemic *Compositae* of Crete. Moreover, the relict, old, and fairly old endemic species, taken together, are far from negligible either in species numbers or as an element of the vegetation of a given district.

CRETAN ENDEMIC COMPOSITAE.

Since it is impossible to publish here a full account of the distribution of each species endemic to the Balkan Peninsula, for this would require a volume, I have selected the 25 species of *Compositae* endemic to the island of Crete as an example of my methods. Three species which probably extend to the island of Karpathos are included.

Data. The two accepted species of the genus *Ammanthus* are limited to the extreme north-east of Crete, *Ammanthus filicaulis* Boiss. et Heldr. to the Sidero Peninsula, *A. maritimus* Boiss. et Heldr. to the Sidero Peninsula and Yanisada. They are annuals flowering in April and May. Two other species have been described by Gandoger, *Flora Cretica* 55 (Paris, 1916). Of these *A. tomentellus*, as represented at Kew by a specimen of a type-number 739, is a species of *Anthemis* with distinct receptacular scales, but the specimen is so poor that I am uncertain of the species. The other, *A. intermedius*, I have not seen

and therefore reject for the present purpose. The two species described by Boissier and Heldreich are very closely allied morphologically and very probably represent varieties or mere fluctuations of one species. There are, however, several morphological differences which appear to have a constant association, and it is possible that there is a physiological isolation which can only be detected by detailed cultural and experimental studies. The genus is sunk in *Chrysanthemum* by Bentham and Hooker and by Thonner. Owing to the very artificial character of the genera of this section of the *Compositae* it is difficult to suggest affinities, but some species of *Anthemis* seem morphologically more closely related to *Ammanthus* than do species of *Chrysanthemum*. In habit and vegetative development *Cotula cinerea* Delile also shows marked resemblances, especially with *A. maritimus*. One judges that the genus is relatively old.

Bellis longifolia Boiss. et Heldr. is a low perennial herb flowering from April to June. It is morphologically allied to *B. silvestris* Cyr. and in Crete is altitudinally pseudo-vicarious with this species, occurring at higher altitudes. Two varieties occur: α *longifolia* Turrill at Amalos in Mt. Sphakia and Mt. Aphendi-Kavutsi, and β *glabrata* Raul. in Mt. Aphendi-Lassiti. The species is possibly of fairly recent origin.

Centaurea argentea L. is a perennial herb flowering in June and July. It is limited to western and southern Crete: Grabusa promontory, Hagios Elias in distr. Kissamos, Mt. Kophino in distr. Monofatri, Hagia Rumelia, and Muliana. Morphologically it is a relatively isolated type of the Sect. *Cyaneae* DC., Subsect. *Acrolophus* DC. There is certainly no taxonomically closely related species known from Crete and the species is probably old.

C. baldaccii Degen is a perennial herb flowering in July. It occurs only on the peak of Mt. Volakia in the Sphakia mountains. Morphologically it is related to *C. pindicola* Griseb., known from Mts. Olympus and Ossa in Thessaly. Taxonomically it belongs to the Sect. *Cyaneae* DC., Subsect. *Cyanus* DC. Probably it is an old species having been in Crete before the island separated from the mainland.

C. idaea Boiss. et Heldr. is a biennial species flowering from June to August. It is morphologically close to the widely distributed *C. solstitialis* L. of the Sect. *Calcitrapeae* DC. It has a fairly wide distribution in western and central Crete: Kissamos, Malaxa, Stylos, Kephala, Anopolis, Aradhena, Mt. Ida, Spilia (ultra Temenos), Tybaki, Tybaki-Klima, and Knossus. Probably the species is a recent one.

Centaurea lancifolia Sieb. is a perennial herb flowering in July. It is placed in the Sect. *Seridieae* DC., of which two other species, *C. sphaerocephala* L. and *C. napifolia* L., have been recorded from Crete,

though neither has been collected recently. The species is apparently limited to western Crete (Sphakia and Drakona) and may be fairly old.

C. redempta Heldr. A perennial herb flowering in June and July. It is limited to western Crete: Kissamos, Malaca, and Homalos. *C. laconica* Boiss. (*C. subarachnoidea* Hal.) from Mts. Malevo and Taygetos is related to this species and is vicarious with it. It is probably fairly old.

Cirsium leucocephalum Spreng. is a biennial herb flowering in July and August. It was described from Crete without exact locality and must be judged an old species since it is morphologically most nearly akin to *C. heldreichii* Hal. from Thessaly and Eurytania.

C. morinaefolium Boiss. et Heldr. is a biennial herb and flowers in July and August in the montane and high mountain zones. It is recorded from the Sphakia and Psiloriti massifs. Morphologically it is most nearly related to *C. hellenicum* Boiss. et Orph. from Thessaly and the Peloponnese, and is probably an old species.

Crepis auriculaefolia Sieber is a perennial herb flowering from April till June in the hill and montane zones of the Sphakia and Lassiti mountain groups and from Kritza in the Mirabello district. It is altitudinally vicarious with *C. raulinii* Boiss.

C. raulinii Boiss. is a perennial herb of the highest mountain zones flowering from May to July and altitudinally vicarious with *C. auriculaefolia* Sieber. It is known from the Sphakia and Psiloriti mountain groups.

C. sibthorpiana Boiss. et Heldr. is a perennial herb morphologically related to and geographically vicarious with *C. divaricata* Boiss. et Heldr. from Taygetus and (?) the Belasitsa. It occurs in the montane and high mountain zones in the Sphakia and Psiloriti massifs.

Helichrysum heldreichii Boiss. is a low shrubby plant flowering in June and known only from the Rumeli gorge in south-western Crete. It is related to *H. siculum* Boiss. which has a wide distribution from the East Mediterranean basin west to Sicily and southern Italy and is widely spread in Crete. It may be fairly recent.

Hypochaeris tenuiflora Boiss. is a perennial herb flowering in June in the second high mountain zone. It is only known from Mt. Hellinoseli in the Sphakia group and is related morphologically to *H. cretensis* Bory et Chaub. with which it is altitudinally vicarious.

Inula limonifolia Boiss. is a perennial, with a dense white indumentum, related to *I. candida* L. and several other species of the group occurring in the eastern Mediterranean area. It is especially found on rocks near the sea in the Kissamos and Sphakia districts, and flowers in June and July. It is possibly fairly old. The plant recorded from Karpathos as *I. candida* L. may be this, but I have seen no specimens.

Lactuca acanthifolia Willd. is an incompletely known species from

hills of the Maleka promontory in western Crete. It is probably most closely related morphologically to *L. amorgina* Heldr. et Orph. from the island of Amorgos, and may be fairly old.

Leontodon taraxacifolius Hal. has apparently been collected only by Sieber. It was first described as *Deloderium taraxacifolium* Cass. in *Dict. Sci. Nat.* xlviii. 430 (1827), where it is cited as from the 'environs de la Canée, dans l'île de Candie'. It is placed by Halácsy in the section *Annui*, to which also belong *L. hispidulum* (Del.) Boiss. from Egypt (Alexandria) and Arabia to Syria, Irak, and Persia, and *L. arabicum* Boiss. from Arabia. The species is probably fairly old.

Phagnalon pumilum S. et S. is morphologically a well-marked species endemic to the highest mountain zone of the Sphakia mountain group in western Crete. It flowers in June and July and is morphologically related to *P. kotschyi* Sch.-Bip. from Syria and Kurdistan. Two varieties are easily recognizable: α *tomentosum* Raul., with a white tomentum, and β *glabrum* Boiss., nearly or quite glabrous.

Scorzonera cretica Willd. is a perennial herb which is known from a number of localities in Central Crete on both the north and south sides of the east and west chain: Tybaki, Hag. Triada, Knossus, Arkhanes (distr. Temenos), and Prinias. It is related morphologically to *S. doriae* Degen et Baldacci, a species from Thessaly, Epirus, Albania, North Macedonia, and Hercegovina. The species may be fairly old.

S. lassitica Vierh. is a perennial herb which is known only from the Lassiti mountain group in eastern Crete. It is morphologically allied to *S. hirsuta* L. which is distributed from Sicily and southern Italy westwards to Spain. The species may be fairly old.

Senecio fruticulosus S. et S. is a perennial herb which flowers in July and August in the montane and high mountain zones. It is recorded from the Sphakia and Psiloriti mountain massifs and is morphologically closely related to *S. rupestris* W. et K. which also occurs in Crete. The species may be of recent origin.

S. gnaphalodes Sieber is a perennial shrubby species flowering from June to August and found on rocks in the lower zones in eastern Crete (Magula, Sitia, Sidero). It is also known from the island of Karpathos. The species is morphologically rather a distinct one and may be fairly old.

Staehelina arborescens L. is a perennial herb flowering in July and August in rocky habitats in the lowland to the montane zones. It is widely distributed in Crete, but does not occur in large numbers of individuals. It is known from the districts of Kisamos, Sphakia, Rethymo, and Canea, from Mt. Kophino, and from the island of Dia. The species is morphologically a very distinct one and must be regarded as fairly old.

S. fruticosa L. is a perennial herb flowering from June to September in rocky habitats in the montane zone. It is known from the Sphakia and Lassiti mountain groups and is a very distinct species which may be fairly old. It occurs also outside the main island in Karpathos, in the islet of Saria to the north of Karpathos, and in the islet of Kasos to the south-west of Karpathos, between it and Crete.

Summary. Twenty-five species belonging to 14 genera of *Compositae* are enumerated above as endemic to the island of Crete. The total number of species of the family accepted as occurring in Crete is 178. Judging solely from morphological and phytogeographical facts it is suggested that 2 of the endemics may be of recent origin, 2 fairly recent, 10 fairly old, and 5 old. Four species are geographically or altitudinally vicarious, and the two species of *Ammanthus* probably represent a relatively old type, though one or both may be recent as species. It is noteworthy that a majority of species have a limited distribution and the following table indicates their probable relative age on the above criteria.

	From one locality or a limited area	*From two or three isolated localities*	*Fairly widely spread in the island*	*Widely spread over the island*	*Totals*
Recent . .	..	1	..	1	2
Fairly recent .	1	1	..	..	2
Fairly old. .	5	2	2	1	10
Old . . .	5	2	..	..	7
Vicarious . .	1	3	..	..	4
Totals . .	12	9	2	2	25

The criteria used above are acknowledged to be unsatisfactory and no absolute value can be attached to the classification of the figures. They do, however, suggest that a majority of the endemics are old, unless it be supposed that their evolution has been by bigger mutations that we have at present any right to postulate.

As regards dispersal mechanism, all except the 2 species of *Ammanthus*, *Bellis longifolia*, and 2 species of *Centaurea* have a well developed pappus. The efficiency of the pappus mechanism has been a matter of much dispute, but Small[1] concludes 'that the ordinary pappose fruit under the proper meteorological conditions can be blown many hundreds of miles over land and sea'. Excluding the 5 species referred to above the fruits of all the remaining Cretan endemic *Compositae* have a size and structure which would appear to make easy their effective

[1] Small, J., *The Origin and Development of the Compositae*, New Phytologist Reprint, No. 11 (London, 1919).

dispersal by the wind velocities tabulated by Small (p. 182) and many of them should be widely dispersed by the lower minima stated. It is difficult to suggest why many of the *Compositae* listed above are so local. It appears unlikely on morphological and phytogeographical grounds that they are so recent that they have not had time to disperse, nor would suitable habitats in other parts of Crete or in the adjacent mainland appear to be lacking. It is very probable that ecesis is of considerable importance, and that the balance of factors leading to successful establishment is a very delicate one, even if the fruits reach a new habitat which superficially appears suitable. The biotic factor, especially the feeding preferences of the sheep and goats, may also be a factor in limiting effective dispersal and ecesis, or even in reducing the distributional area. Since annuals and perennials are both represented amongst the plants now under consideration, since they occur in various altitudinal zones, and since they have varying flowering periods, it is very probable that different factors have been or are the cause of the usually limited distribution, and there is no evidence that these cancel one another out so as to leave a clear field for the gradual increase of area with the age of a species.

RELICT PLANTS OF THE BALKAN PENINSULAR FLORA.

General. It has been shown that the flora of the Balkan Peninsula shows a high degree of endemism for the species and that the endemics are of various degrees of taxonomic distinctness and of age. It has been concluded on taxonomic and phytogeographical criteria that the majority of the endemics have originated, as species, within the area considered in this work. There are, however, a number of species which, judging from their taxonomic and geographic isolation, represent an older flora than that predominating now. Although fewer in number than the younger species, and often less characteristic of existing communities, they are of considerable importance in any attempt to sketch the history of the flora. It is usually impossible to decide whether the species as such, that is with all their inclusive and exclusive taxonomic characters, are actually old or whether they represent relatively old types. For example, there can be no doubt that the *Gesneriaceae* of the Balkan Peninsula are a relict group. *Ramondia heldreichii* Benth. et Hook. f. and *Haberlea rhodopensis* Friv. are probably old species, but *H. ferdinandi-coburgi* Urum. is probably a recent mutation, which breeds true but is not yet, in nature, completely isolated from its parent *H. rhodopensis*. As a type it is a relict, or would be if *H. rhodopensis* became extinct; as a species (or variety) it is young. Again *Ramondia serbica* Panč. and *R. nathaliae* Panč. et Petrov. are very probably derived from a common type. Both may be young as

species, but together they represent a Tertiary type, and are now taxonomically isolated in the Balkan Peninsular flora and geographically isolated from their nearest morphological allies. Wide taxonomic isolation and wide geographic isolation are then the criteria used for picking out the relict species and small groups of species. For some woody plants there is some reliable palaeontological evidence. In addition to the relict endemics there are many species extending beyond our boundaries which are certainly relicts. They are included for consideration here.

Relict species, with distributional and other data. The species follow the sequence of families of the Engler and Prantl classification.

Taxus baccata L. is known from Greece, Thessaly, Albania, North and South Macedonia, the Athos Peninsula, North and South Bulgaria, the Rodope massif, Serbia, Montenegro, Bosnia, Hercegovina, Dalmatia, Croatia, and Istria. One species, with 7 varieties or subspecies, is usually recognized, spread over large parts of North America, Europe, Algeria, and Asia. Authorities are unanimous that the yew was formerly more widespread in Europe than it is to-day, and the palaeontological and archaeological evidence strongly supports this view. On the other hand, I know of no reliable fossil records for *Taxus* older than middle Tertiary, and the genus may be of Tertiary origin.

The *Pinaceae* as a whole represent more ancient types than the angiospermous families, but it will suffice to mention two species which are certainly relicts. *Picea omorika* Willk., endemic to western Serbia, Montenegro, and Bosnia, is the sole existing European representative of the section *Omorika*, whose other extant species occur in eastern Asia and North America. An allied species, *P. omorikoides*, has been fully described from leaves and cones by Webber [in *Engler's Bot. Jahrb.* xxiv. 510 (1898)] from Aue in Saxony, in a pre-glacial deposit which is of the same age as the Cromer forest bed, i. e. Upper Pliocene. Lokowitz has also found near Mulhouse, in Alsace, in middle Oligocene beds, some remains of a spruce which resembles *P. omorika*. A very full account of the ecology of the forests with *P. omorika* is given by Wettstein in *Oesterr. Bot. Zeitschr.* xl. 357 (1890). *Pinus peuce* Griseb. is endemic to Albania, North Macedonia, North Bulgaria, the Rodope massif, Serbia, and Montenegro. It is a beautiful tree with five needle leaves on each dwarf shoot, and is not uncommon in mixed conifer woods in our altitudinal zone 5a. Its nearest taxonomic relative is *P. excelsa* Wall. from the western Himalayas.

Narthecium scardicum Košanin from Albania, North Macedonia, and Montenegro is the only species of the genus known from the Balkan Peninsula. It is taxonomically closely related to *N. reverchonii* Čelak. from Corsica and *N. balansae* Briq. from the Caucasus. *N. ossifragum*

Huds. is widely spread in Atlantic Europe, *N. asiaticum* Maxim. is known from Japan, and there are two described North American species. The scattered distribution of the genus and the wide discontinuity between the species indicates a relict nature for *N. scardicum* Košanin in the Balkan Peninsula.

Smilax aspera L. and *S. excelsa* L. both belong to the section *Eusmilax* DC., the largest section of the genus and represented by numerous species in the tropics and subtropics of the Old and New Worlds. *S. aspera* L. has a wide and fairly continuous distribution throughout the whole of the Mediterranean Region and is also recorded from northern India and Abyssinia. *S. excelsa* L. is found on the southern littoral of the Caspian Sea, throughout the Caucasus, and the Pontic ranges as far as the Sea of Marmara, and in isolated areas in Thrace and in southern and eastern Bulgaria. Its nearest taxonomic allies are *S. divaricata* Solander ex Stapf and *S. canariensis* Willd. from the Atlantic islands. There is no doubt that *S. excelsa* is a relict type of a more or less subtropical flora which in Tertiary times stretched widely across southern Europe and western Asia, has left many scattered and isolated species throughout that area, and has locally survived in still unbroken communities on the shores of the Black Sea and in the forests of the Caucasus and North Persia.[1]

Dioscorea balcanica Košanin is the only species of the genus in the Balkan Peninsula. Its nearest taxonomic ally is *D. caucasicum* Lipsky from the Caucasus. It is limited to northern Albania and is another relict of the Tertiary flora known from this and neighbouring areas.

Juglans regia L. has a wide distribution in the Balkan Peninsula and is certainly native in many of the districts. It is not recorded for Crete, Dalmatia, or Istria. In 1926 I studied a fine natural wood of this species in the south Central Rodope, between Buju and Daridere, where it grew with *Fagus orientalis* Lipsky and *Ostrya carpinifolia* Scop. It extends eastwards through Asia Minor, the Caucasus, Persia, and the Himalayas to Burma, North China, and Japan. About 15 species of the genus are known, occurring in south-east Europe, through much of Asia, and in various parts of America. The genus is certainly an old one, being well represented in fossil floras from the base of the Upper Cretaceous to Quaternary times. The range of *J. regia* in Europe has become much restricted in recent geological times. Thus in the Pliocene of Central France a considerable number of occurrences have established that the Auvergne was evidently well wooded with this species before the advent of the human race. During the Pleistocene the walnut left its remains in a number of localities in northern Italy, in Hanover, and in Provence, and nuts found in the Swiss

[1] See Stapf in *Bot. Mag.* t. 9067, 1925.

lake dwellings were undoubtedly from wild trees. A species of *Juglans* has been described from the Fayum.[1] It is thus evident that it is correct to consider *J. regia* in the Balkan Peninsula as a relict species in spite of the fact that its distribution eastwards is still fairly continuous.

Ostrya carpinifolia Scop. This species has a wide distribution in the Balkan Peninsula, but I have not seen it from Crete, the Cyclades, South Macedonia, or North Bulgaria. The other living species of the genus are *O. knowltonii* Coville, a rare tree in Arizona, *O. virginica* Willd., found in Canada and the U.S.A., *O. japonica* Sarg. from Japan, China, and probably Manchuria, and three species described by Rose from Mexico and Central America. *O. carpinifolia* Scop. occurs from south-west France eastwards to Asia Minor and Syria. The sac-like involucre of the female flower, open at flowering but closed when fruiting, distinguishes the genus from *Carpinus*. Several fossil species are recorded from Tertiary deposits, and these indicate a more continuous area of distribution for the genus in the past than now.

Fagus orientalis Lipsky is distributed from the Caucasus along the Pontic ranges of northern Asia Minor to the Bithynian Olympus, and in the eastern parts of the Balkan Peninsula it is known from the Strandja, from north of Varna, and from the southern Rodopes, and probably occurs in the Dobruja. It is in general vicarious with the common beech, and in the Balkan Peninsula occurs at lower altitudes. A very closely related species, perhaps even conspecific with *F. orientalis*, has been described and figured from Pliocene beds in southern France as *Fagus pliocenica* Sap.[2]

Zelkova abelicea Boiss. occurs in Crete and Cyprus and is taxonomically nearest to *Z. crenata* Spach from the Caucasus and North Persia. There are about four species of the genus known from China and Japan. *Celtis* is taxonomically the most closely allied genus, though there are some morphological resemblances to the North American genus *Planera*. The species is very isolated in our flora.

Commandra elegans Reichb. is known from Greece, Thessaly, Albania, North and South Macedonia, Thrace, North and South Bulgaria, the Rodope massif, and Serbia. Outside the Balkan Peninsula it is recorded only from the Banat and Roumania. All the other species (about five) occur in North America. On the phytogeographical evidence our species must be considered as a relict of the Tertiary flora which was formerly common to the North Temperate Region.

Osyris alba L. is known from nearly all the Mediterranean and transitional districts of the Balkan Peninsula. Its general distribution is from Portugal and North Africa throughout the Mediterranean Basin

[1] See Berry, *Tree Ancestors*, 76, Baltimore (1923).

[2] See Depape in *Ann. Sci. Nat. Bot.*, Xe. Sér. iv, 143–4 (1922).

to Asia Minor, Cyprus, Syria, and Palestine. Another species occur in Spain, two others in China and India, and about eight in Africa. The species probably represents an old African floristic connexion, a few traces of which have remained in the Mediterranean from Tertiary times.

Cleome aurea Čelak. is known from the Athos Peninsula, Thrace, the Rodope massif, and South Macedonia. Its nearest taxonomic affinity is with *C. ornithopodioides* L., which is recorded from Asia Minor, eastwards to the Caucasus, Crimea, and Persia. About 19 other species are known from Egypt, Arabia, Persia, Afghanistan, and the Caspian area. The remaining species of the genus occur in the warm and tropical regions, especially of America. Probably *C. aurea* represents a late Tertiary extension of the genus westwards, rather than a relict comparable with those already mentioned.

Platanus orientalis L. is now widely dispersed as a spontaneously reproducing tree or shrub in many parts of the Balkan Peninsula. It is certainly native in the south and south-east of our area from Crete and Greece through South Macedonia, Thrace, and the Rodope massif. An evergreen variety occurs in Crete. The other five known extant species of the genus are now confined to America and the palaeontological evidence points to an American origin for the genus in Mesozoic (probably Cretaceous) times. Fossil remains of *Platanus* of Eocene age occur in North Europe, of Miocene age in many parts of Central Europe, and of Pliocene age in Italy along the foothills of the rising Apennines, in France, Spain, Styria, and Slavonia. There is no doubt that *Platanus* is a Tertiary relict in the European flora.

Rheum rhaponticum L. from the Rodope massif (Rila) also occurs in Siberia (Altai). In the Balkan Peninsula it is a mountain plant, but in Central Asia it is said to grow in the steppes. The latest evidence is in favour of its being native in both areas, and since it is the only species of the genus wild in Europe its origin in our flora probably dates back to Tertiary times.

Laurus nobilis L. is known from Crete, Greece, Thessaly, Epirus, Albania, the Athos Peninsula, Thrace, Hercegovina, Dalmatia, South Croatia, and Istria, in the Balkan Peninsula. Its general distribution is from Portugal to the Crimea, much of Asia Minor, Syria, Palestine, the Caucasus, and western North Africa. *L. canariensis* L., the only other extant species of the genus as now accepted is from Madeira, the Azores, and the Canaries. *Laurus* is known as a fossil from Pliocene deposits of the Mediterranean Basin.

Sibiraea croatica Degen is known from South Croatia, Mt. Velnac above Carlopago, 970–1,023 m., and from Hercegovina, Čabulja Planina, near Mostar, 1,400–1,500 m. It is morphologically very closely

related to *S. laevigata* Maxim. from the Altai, and Schneider (in *Dörfler Herb. Norm.*, No. 4625, 1906) reduces it to a variety of this species. The differences are mainly in habit and their constancy can only be tested by experiments. *S. croatica* is certainly wild in the Balkan Peninsula, and its general distribution is comparable with that of *Rheum rhaponticum*. There is no doubt it is a Tertiary relict of an interesting character.

Ceratonia siliqua L., the only species of the genus, is recorded from Crete, Greece, the Cyclades, Dalmatia, and Istria. Its general distribution is throughout the Mediterranean Basin in South Europe, North Africa, and the Levant. It is taxonomically isolated in the existing flora and is certainly a relict type.

Cercis siliquastrum L. occurs in Crete, Greece, Cyclades, Thessaly, Albania, South Macedonia, the Athos Peninsula, Thrace, South Bulgaria, North Bulgaria, Dalmatia, and Istria. Its general distribution is from South France north to the southern Tyrol and east to North Persia. *C. griffithii* Boiss. occurs in Afghanistan, *C. chinensis* Bunge in China and Japan, *C. occidentalis* Torr. in California, and *C. canadensis* L. in eastern North America. The oldest known fossils of this genus come from the Lower Eocene, and these are all North American. Middle and Upper Eocene, Oligocene, Miocene, and Pliocene fossil forms are known from Central European deposits. There is no doubt that the species in Europe is a relict of Tertiary times, at the end of which its congeners were destroyed and its area curtailed by the coming of the Ice Age.

Buxus sempervirens L. is known from Greece, Thessaly, Epirus, Albania, North and South Macedonia, Thrace, and Dalmatia. It is thus mainly western in its distribution in the Peninsula where it occurs especially on serpentine substrata and avoids limestone. Its general distribution is wide but often discontinuous from western Europe through the Mediterranean Region to the Caucasus and Persia. The section *Eu-buxus* comprises about 10 species, natives of Tropical Africa, the Mediterranean Region, the Himalayas, China, and Japan. In the Balkan Peninsula *B. sempervirens* is probably a relict of Tertiary times.

Coriaria myrtifolia L. is known only from Greece, in our area. It is spread chiefly in the western Mediterranean Basin and an apparently nearly related species has been described from the Miocene of southwest Europe. About 7 other living species are described from Asia, America, and Australasia. Our species is certainly a Tertiary relict in the Mediterranean flora.

Cotinus coggygria Scop. has a very wide distribution in the Balkan Peninsula, but is not known from Crete. Its general distribution is through much of the Mediterranean Region and the southern parts of

Central Europe to the Himalayas and China. Another species occurs in North America and has sometimes been considered as a variety of ours. Several fossil species of Tertiary age have been described, and there is no doubt that *C. coggygria* is a Tertiary relict.

Pistacia lentiscus L., *P. mutica* Fisch et Mey., and *P. terebinthus* L. are essentially Mediterranean or transitional in their distribution in our area. Other species are known from the Mediterranean Region, eastern Asia, and Mexico. Various Tertiary fossils have been referred to this genus, which must be considered as a relict from the Tertiary epoch.

Rhus coriaria L. is recorded from Greece, Thessaly, Albania, North and South Macedonia, the Athos Peninsula, Thrace, North Bulgaria, Montenegro, Hercegovina, and Dalmatia. Its general distribution is fairly continuous throughout the Mediterranean Region. The genus contains about 150 known species widely distributed in subtropical and warm regions. Species have been described as fossils from Tertiary beds of both the Old and New Worlds. Our species is very probably a Tertiary type.

Ilex aquifolium L. has a very wide distribution in our area but is not known to occur in Crete. The genus includes about 270 species distributed throughout the greater part of the temperate and tropical regions of the world. The common holly is a native of western and southern Europe, extending eastwards to Asia Minor, the Caucasus, North Persia, and China. It certainly dates from Tertiary times in the Balkan Peninsula and represents the last of a genus which before the Ice Age was represented in Europe by many species.

Staphylea pinnata L. is known from North Bulgaria, the Rodope massif, Dobruja, Serbia, Montenegro, Bosnia, South Croatia, and Istria. Its general distribution is from Alsace, Baden, and Bavaria eastwards to Bithynia, Pontic Asia Minor, and the Caucasus. *S. colchica* Steven is eastern Pontic and *S. emodi* Wall. reaches Afghanistan from North India. There are about 6 species known from China and Japan and 3 or 4 from North America south to Mexico. It is uncertain if our species is rightly considered a relict, or is not an illustration of the spread of eastern Pontic–Oriental species across the Balkan Peninsula and in recent times into Central Europe.

Aesculus hippocastanum L. is known as a native from Greece, the Pindus, Epirus, and North Bulgaria. As a truly wild tree it is possibly limited to the Balkan Peninsula where its distribution is discontinuous. About 11 other species of the genus are known from Asia (Afghanistan and eastwards) and North America. There is no doubt that our species is a relict from Tertiary times.

Paliurus microcarpus Wilmott and *P. spina-Christi* Mill. are the

representatives of a genus with about six species in China and one in Tonkin. Most of the latter are not widely different from the common Christ's thorn. *P. microcarpus* is probably a recent mutant from *P. spina-Christi* and at present is doubtfully kept as a species. The fruits certainly recall those of *P. ramosissimus* Poir. in shape, but the resemblance is superficial. *P. spina-Christi* has a wide distribution from Spain to Persia.

Wulfenia baldaccii Degen and *W. carinthiaca* Jacq. are the only European species of this genus of the *Scrophulariaceae*. The former occurs in the North Albanian mountains at 1,600–2,000 m., and the latter in Montenegro, Novi Pazar, and the North Albanian mountains at 1,600–2,300 m., and, outside the Balkan Peninsula in South Carinthia and Friuli (Prov. di Udini). Scharfetter [1] argues that its occurrence in Carinthia is post-glacial and that Montenegro is probably an original relict station. The only other certain species of the genus are *W. orientalis* Boiss. from North Syria and *W. amherstiana* Benth. from Afghanistan and North India. The genus is allied taxonomically to *Veronica*, but differs markedly in habit. Other genera more like it in habit are: *Lagotis* (Central and North Asia, Arctic, Himalayas), *Falconeria* (western Himalayas), *Calorhabdos* (Japan and Himalayas), and *Synthyris* (North America). Some authors make the last genus a synonym of *Wulfenia*, which then becomes a very much less uniform genus structurally, and even more discontinuous geographically (see, however, Greene in *Erythea*, ii. 80, 1894). The two Balkan Peninsular species certainly, as type or as species, are Tertiary relicts.

Lathraea rhodopea Dingler, from several localities in the Rodope massif, is endemic to the Balkan Peninsula and is taxonomically less nearly related to *L. squamaria* L., which is widely distributed in the northern and central parts of our area, than to *L. japonica* Miq. from eastern Asia. It appears to be a relict dating from Tertiary times.

Zizyphus lotus Desf., from Greece, and *Z. jujuba* Mill., from most of the Mediterranean and transitional districts of the Balkan Peninsula, represent a genus of more than 40 species distributed in the tropical and subtropical regions of both the Old and New Worlds. A considerable number of fossil species have been described from Tertiary strata of Europe and North America, and our species are certainly relict types.

Vitis vinifera L. The vine is undoubtedly wild in some parts of the Balkan Peninsula, and the wild plant has been distinguished from the cultivated as a species under the name *V. silvestris* Gmel. The known palaeontological and archaeological facts prove that it was formerly native over a wide area in Europe, and it must now be considered as a relict of Tertiary vegetation.

[1] *Oesterr. Bot. Zeitschr.* lviii. 398 seq. (1908).

Myrtus communis L. is a typical representative of the Mediterranean macchie in the Balkan Peninsula. Its general distribution is through the Mediterranean Region. The genus is found in most of the warmer parts of the world and dates from Tertiary if not from Mesozoic times.

Trapa natans L. is known from North and South Macedonia, Thrace, North and South Bulgaria, Dobruja, Serbia, Hercegovina, Dalmatia, and South Croatia. The palaeontological, archaeological, and historical evidence proves it to have had a much wider distribution in the Balkan Peninsula and in Europe generally in past Quaternary and Tertiary times.

Rhododendron ponticum L., known from the Strandja Planina in South Bulgaria, is a relict species in Europe. It occurs in Portugal and southern Spain and has been recorded as fossil in interglacial beds in the Alps. The fossil record for Skyros I am convinced is based on an inaccurate identification.

Diospyros lotus L. is known from Greece, Thrace, Dalmatia, and South Croatia. It is widely spread in the Nearer East and is also said to occur wild in China. The species of the genus are mostly tropical and subtropical in both the Old and New Worlds. Numerous fossil species from Mesozoic and Tertiary strata have been described from many parts of the world including most European countries. From Middle Cretaceous to Pliocene times the fossil record indicates that *Diospyros* flourished in the Mediterranean Basin and all the evidence points to our species being a relict type from Tertiary times at least.

Styrax officinalis L. occurs in Crete, Greece, the Cyclades, Thrace, and Dalmatia. It has a fairly continuous distribution within the Mediterranean Basin. The genus is widely distributed in Asia and America and various species have been described fossil from the Tertiary of Europe and North America. Our species is certainly a Tertiary type.

Forsythia europaea Baldacci, from northern Albania and Novi Pazar, is a very definite relict. The remaining known species, about 5, of the genus are endemic to China and Japan.

Olea europaea L. occurs as a wild plant (var. *oleaster* DC.) in the Mediterranean and transitional districts of the Balkan Peninsula, especially in the macchie. The olive has now a wide distribution throughout and beyond the Mediterranean Region. The numerous species of the genus occur especially in South Africa, south-east Asia, and Australasia. Various fossil species have been described from European Tertiary deposits but the identifications are mostly doubtful. Probably the wild olive does, however, represent a Tertiary relict.

Syringa vulgaris L. is a common constituent of shiblyak in the central and northern parts of the Balkan Peninsula and extends into east

Central Europe. The headquarters of the genus are now known to be in eastern Asia, and the European species are certainly Tertiary types.

Apocynum venetum L. is known from Thrace, South Bulgaria, Dobruja, and Istria and extends from North Italy to China. Nearly all of the remaining species are North American. It is possible, but by no means certain, that our species is a relict in the Balkan Peninsula.

Nerium oleander L. is wild in most of the Mediterranean and transitional districts of the Balkan Peninsula, where it occurs especially along stream-sides. It has a general distribution throughout the Mediterranean Region. Two or three other species are known from the Nearer East and one even extends to India and Japan, while another species has been described from Penang. I know of no fossil evidence, but the genus probably dates from Tertiary times.

Solenanthus albanicus Degen et Baldacci from Epirus, *S. apenninus* Hohen. from north-west Albania, central and southern Italy, and Sicily, *S. scardicus* Bornm. from North Macedonia, and *S. stamineus* Wettst. from Greece, eastern Asia Minor east to north and west Persia, are the species of this genus recorded from the Balkan Peninsula. The headquarters of the genus are in the eastern Orient and Central Asia. The European species, with a very discontinuous distribution, are relicts in the sense that the genus probably extended from the eastern Orient and Central Asia into the Mediterranean Basin in Tertiary times but has largely disappeared, and the Balkan Peninsula species were probably not derived immediately from one another.

Haberlea ferdinandi-coburgii Urum., from North Bulgaria, and *H. rhodopensis* Friv., from North Bulgaria and the Rodope massif, constitute an endemic genus. *Ramondia heldreichii* Benth. et Hook. f. from the Thessalian Olympus, *R. nathaliae* Panč. et Petrov. from North Macedonia and Serbia, and *R. serbica* Panč. from Epirus, Albania, North Macedonia, and Serbia are all endemic, and the only other species of the genus is *R. pyrenaica* Rich. from the Pyrenees. The relationships are with Chinese species, especially of the genera *Didissandra* and *Boea*. Although there is no palaeontological evidence it is safe to consider the Balkan Peninsular *Gesneriaceae* as a whole as representing Tertiary relicts.

Petromarula pinnata DC. is a monotypic genus endemic to Crete. It is most closely related to *Phyteuma* and *Asyneuma* and is probably a relict.

Symphyandra cretica A. DC. occurs in Crete and Samothrace (as the var. *samothracica* Degen), *S. hofmannii* Pant. in Bosnia, *S. panagea* Heldr. et Nadji is a doubtful species from South Macedonia, *S. soradum* Hal. is from the Magnesian islands, and *S. wanneri* Heuff. from the Banat, Transylvania, North Bulgaria, the Rodope massif, and Serbia. In addition there are 7 or 8 species known from the Caucasian

and Pontic areas and *S. asiatica* Nakai from Korea. The distributional and taxonomic facts suggest that the species of a Tertiary genus have been isolated geographically while evolving from a formerly widespread ancestral type.

Amphoricarpus Vis. This genus was first described from the Balkan Peninsula (Mt. Orien, Dalmatia), the name species being *A. neumayeri* Vis. The morphological relationships are with *Xeranthemum* (Mediterranean Region), *Chardinia* (Asia Minor to Persia), and *Siebera* (Asia Minor and Syria to Iraq and Persia). The present known distribution of the species *A. neumayeri* Vis. is Albania, Montenegro, Hercegovina, and South Dalmatia. A specimen at Kew was collected by Professor Košanin in 'Macedonia' m. Jalica: supra faucem Sija, 12. viii. 19, but I have not traced this locality. The plant grows in stony and rocky ground in the highest mountain zones (5b–5c) and flowers in July and August. A variety was described by Murbeck [1] as var. *velezensis*. This variety is now known from several parts of the species area, and intermediates between it and the var. *neumayeri* are preserved at Kew. The only other species of the genus has been described and figured as *A. elegans* by Alboff in *Bull. Herb. Boiss.* ii. 248, pl. vii. (1894). This plant has been collected in two districts of western Transcaucasia (Mingrelia and Abchasia). Alboff considers its differences from *A. neumayeri* sufficient to consider it as the type of a new section which he names *Chodatella*. Judging from his figures and description, and from the one sheet at Kew, it appears to be undoubtedly morphologically related, though not closely, to the Balkan Peninsular species, and Alboff's classification seems reasonable. We have thus to conclude that *A. neumayeri* Vis. is a 'relict' species in the sense that it is morphologically isolated in the Balkan Peninsular flora and geographically widely isolated from its only congener. The supposition of Alboff is that the genus once extended at least from Transcaucasia to the Balkan Peninsula, but it is also possible that the genus is polyphyletic and that its two species have arisen independently in separate countries.

The following species, not mentioned above, might also be considered as Tertiary relicts:

Pinus leucodermis Ant., *Butomus umbellatus* L., *Hydrocharis morsus-ranae* L., *Stratiotes aloides* L., *Vallisneria spiralis* L., *Erythronium dens-canis* L., *Maianthemum bifolium* F. W. Schmidt, *Lloydia graeca* Endl., *L. serotina* Reichb., *Nectaroscordum siculum* Lindl., *Streptopus amplexifolius* DC., *Tofieldia calyculata* Wahlb., *Pancratium maritimum* L., *Tamus communis* L., *Carpinus betulus* L., *C. orientalis* Mill., *Castanea sativa* Mill., *Celtis australis* L., *C. caucasica* Willd., *Ficus carica*

[1] *Lunds Universit. Årsskr.* xxvii. 100 (1891).

L., *Humulus lupulus* L., *Arceuthobium oxycedri* Bieb., *Loranthus europaeus* Jacq., *Viscum album* L., *Asarum europaeum* L., *Cytinus hypocistis* L., *Atraphaxis billardieri* Jaub. et Spach, *Theligonum cynocrambe* L., *Drypis spinosa* L., *Telephium orientale* Boiss., *Callianthemum rutifolium* C. A. Mey., *Eranthis hiemalis* Salisb., *Isopyrum thalictroides* L., *Trollius europaeus* L., *Epimedium pubigerum* Mor. et DC., *Leontice altaica*

Pall., *L. leontopetalum* L., *Degenia velebitica* Hayek, *Ricotia cretica* Boiss. et Heldr., *Schivereckia dorfleri* Bornm., *S. korabensis* O. E. Schultz, *Aldrovanda vesiculosa* L., *Amelanchier cretica* DC., *A. rotundifolia* Dumont, *Aremonia agrimonoides* Neck., *Aruncus silvester* Kostel., *Cotoneaster pyracantha* Spach, *Cydonia oblonga* Mill., *Mespilus germanica* L., *Prunus laurocerasus* L., *Adenocarpus complicatus* J. Gay, *Anagyris foetida* L., *Biebersteinia orphanidis* Boiss., *Sida sherardiana* Benth., *Datisca cannabina* L., *Elaeagnus angustifolia* L., *Cynomorium coccineum* L., *Hedera helix* L., *H. poetarum* Bert., *Monotropa hypopitys* L., *Cortusa matthiola* L., *Swertia punctata* Baumg., *S. perennis* L., *Rhazya orientalis* A. DC., *Cynanchum acutum* L., *Marsdenia erecta*

R. Br., *Periploca graeca* L., *Polemonium caeruleum* L., *Halacsya sendtneri* Dörfler, *Macrotomia cephalotes* Boiss., *Mattiastrum lithospermifolium* Brand, *Trachystemon creticum* Don, *Scopolia carniolica* Jacq., *Viburnum tinus* L., and *Laurentia tenella* DC.

Conclusions. The above lists will suffice to prove that the Balkan Peninsular flora is rich in relict types. The lists are far from exhaustive and, moreover, there are many genera which we know were well represented in the Tertiary flora of the North Temperate region or which, from their present distribution, we conclude were then in existence, whose Balkan Peninsular species are not listed. Such genera include the following which are largely eastern Asiatic and northern American in present distribution: *Quercus*, *Salix*, *Populus*, *Tilia*, *Cornus*, *Fraxinus*, and *Jasminum*. Also many other genera which are even now evolving species in our area must have existed then, as is indicated by their present distribution. Although a large number of *species* of our flora are probably relatively recent in origin there is no doubt that the flora has its roots in the Tertiary epoch. There has been a continuous evolution of new species in different genera at different periods since Tertiary times. Some genera represented by many microspecies are reaching their zenith, others have passed theirs. The whole evidence from the Balkan Peninsular flora is strongly in favour of Guppy's view that the families have given rise to the genera and the genera to the species. The families are very old, the genera are old, the species of all ages, but there are in our flora many, even of these, that represent the ends of previous phases of evolution. They are relicts.

The precise climatic conditions of the Tertiary epoch in the Balkan Peninsula are unknown, but the available evidence suggests that the relict nature of the plants considered in this section is due to a combination of causes, amongst which the following are important: an often losing struggle with new immigrants, especially from the east, a similar struggle with genera in a phase of strong development of species, a cooling of temperature conditions at the oncoming of and during the Ice Age, and lastly destruction due to human activity, especially of trees. It is not possible to reconstruct the conditions of life in Tertiary times from the present life-conditions of Tertiary relicts, because many of them only survive now by a combination of abnormal factors. Košanin (in *Glas. Srp. Kralj. Akad.* 1923) has noted that *Prunus laurocerasus* L. only survived on Ostrozub as a semi-aquatic, pitiful, sterile form in the waters from a warm spring. Yet *Ramondia serbica* Panč. ranges from near sea-level to 1,600 m. and *R. nathaliae* Panč. et Petrov. even to above 2,000 m. *Picea omorika* Willk. and *Forsythia europaea* Degen et Baldacci have only survived in edaphically unfavourable areas.

The most interesting parts of the Balkan Peninsula for the study of relict species and types are northern Albania and contiguous districts, the Rodope massif, and the Caucasian-Pontic communities of eastern Bulgaria.

DR. WILLIS'S THEORY OF AGE AND AREA AS APPLIED TO THE FLORA OF THE BALKAN PENINSULA.

General. The 'Age and Area' theory and the far-reaching extensions of it made by its author have been the subject of much controversy. Most of those who have written or spoken against it, however, so far as I have been able to determine, have not attempted to apply the methods and conceptions of Dr. Willis either to a taxonomic group or to a floral area, or at least have not published their attempts. Without doubt the papers and book[1] on this subject have stimulated interest in phytogeographical research, and it seemed at first that if the validity of the conclusions reached could be established a royal road to the solution of many of the problems of plant distribution would be opened up. I therefore considered it advisable to study carefully the main thesis and then to apply it to portions of the Balkan Peninsular flora. This, it seems to me, is a fairer test than an attempt to evaluate Dr. Willis's results obtained on floras which I have never studied in detail. In passing, a number of criticisms will be made. These may have a more general application, but it must be clearly understood that their relevancy here is entirely to the Balkan Peninsular flora.

The general expression of the rule of Age and Area as given by Willis on p. 63 of his book[1] is the one which I chiefly wished to test, and it runs as follows:

> 'The area occupied at any given time, in any given country, by any group of allied species at least ten in number, depends chiefly, so long as conditions remain reasonably constant, upon the ages of the species of that group in that country, but may be enormously modified by the presence of barriers such as seas, rivers, mountains, changes of climate from one region to the next, or other ecological boundaries, and the like, also by the action of man, and by other causes.'

The 'time' involved is strictly from the beginning of modern botanical research to the present, say the past 150 years, though there is no reason to doubt that the accepted distributions of the species included, unless otherwise stated, represent the existing distributions. The 'country', unless stated to the contrary, is the Balkan Peninsula, with the boundaries adopted in this work. I have found no definition by Dr. Willis of 'allied' species. Certainly he very frequently takes together species whose only 'alliance' is that they are flowering plants, or at

[1] *Age and Area*, Cambridge, 1922.

most Angiosperms. Thus on pp. 59–60 of his book he lumps together all the Ceylon endemics and *all* the widely distributed species whatever their 'affinities', and there are many other similar examples. It would certainly appear that this proviso is of little importance for establishing the theory. However, it may be presumed that the species of a 'natural' genus, as understood by taxonomists, are sufficiently allied to fulfil this condition. I know of no genus in our flora which contains 'at least ten' definite species so closely allied that they are not classifiable into different sections or subsections and which are so similar in their morphology, physiology, and ecology, that the external factors of the environment would be bound to act upon them with the same results. Nor do I know of two such groups where the 'cancelling out' in each of the factors would yield equivalent results for Age and Area estimates. If this is a *sine qua non* of the successful application of Age and Area then the theory is inapplicable to the Balkan Peninsular flora. In each of the two genera analysed below more than ten species are represented in our flora. I have therefore, fulfilled this condition, as far as possible, in two examples.

A further analysis of Willis's statement is also necessary. 'The area occupied . . . by any group . . . depends . . . upon the ages of the species.' The statement is therefore only applicable when one *group* is compared with another *group*, not for comparing individual species within a group. It happens, however, most frequently in the flora of the Balkan Peninsula that one or more species of a naturally allied 'group' cover the whole of our area. Indeed, I know of no group of ten or more allied species, such as would fulfil Willis's conditions, which does not, often in one or two of its species, include in the contours of its distribution all of my districts, except possibly in a few groups where the influence of the modifying factors is so obvious that it would be unfair to use them for tests of relative or absolute age on the basis of Age and Area.

It follows that the hypothesis of Age and Area cannot here be tested on the basis of Willis's expression. It is only by breaking away from this that any value can be found. Willis himself, Mrs. Reid, Matthews, and others who have, at least in part, accepted the hypothesis that on the whole a larger distributional area is a criterion of greater age in a given country have, in practice, ignored the conditions laid down in the expression quoted above. Willis has so tied up his hypothesis in an endeavour to make it impenetrable to criticism that it has become unworkable in the form in which it is expressed. I can, therefore, only test the value of Age and Area in other ways, but taking the author's practice as a guide. This I have attempted below with the genus *Convolvulus* in detail, the genus *Astragalus* statistically, and

the *Primulaceae* as represented in the flora of the Balkan Peninsula in general terms. In addition it may be recalled that the distributional and taxonomic facts regarding *Hedraeanthus* can, for the species, be interpreted in favour of Age and Area, but that the results of a detailed consideration of the endemic Cretan *Compositae* were unfavourable.

The genus Convolvulus. Twenty species of *Convolvulus* are recorded from the Balkan Peninsula, *Calystegia* being excluded. The taxonomy of all of them is clear with the exception of two, which though here considered as distinct species may have to be united, and of one other, which may be a habitat derivative, and perhaps a form, not a species. The localization of one other species is uncertain. The genus covers the whole area, one or more species occurring in every district. In its general distribution the genus is practically cosmopolitan and some of the species also cover a very wide area. An analysis of the specific distributions is essential before a synthesis is attempted. The species are therefore enumerated separately.

C. persicus L. Dobruja and eastern Thrace, both localities on the Black Sea littoral. The general distribution is on the eastern shores of the Black Sea (on the coast by the western Caucasus) and all round the Caspian Sea. It is the only representative of the section *Pannosi* Boiss. in the Balkan Peninsula, and there is no reason why its limited distribution in our area should not be due to recent introduction, perhaps by man's commercial activities. It is ecologically limited to the strand and could not therefore spread inland. Its absence from the Bulgarian coasts suggests it has not had time to spread from one or other of its stations to which it was introduced independently.

C. cneorum L. Southern Dalmatia and the southern Dalmatian islands. The general distribution is South Italy and Sicily. Boissier, following Sibthorp, records it from Samos but I suspect this is a wrong identification for *C. oleaefolius* Desr. I do not know what climatic or other barrier there could be to a further spread of this species north or south in the Mediterranean domain of the eastern Adriatic. It is therefore possible that it has come in from the south-west and has not yet had time to spread beyond its present area, although if it crossed by a land bridge it should by now have a much more extensive distribution.

C. oleaefolius Desr. Northern Euboea, Attica to Laconia, Cyclades, Crete; with the general distribution: Maltese islands, Rhodes, Cyprus, Tripoli, Cyrenaica, Marmarica, Egypt. The evidence suggests an invasion from the south-east. In Greece it is especially the dry eastern part that is occupied and the moister western parts are not reached. It may be that a climatic barrier, not time, is the limiting factor for this species in the Balkan Peninsula.

C. lanatus Vahl. Crete (*e* Sibthorp), eastern Egypt, and Arabia. The only record in our area is Sibthorp's specimen from Crete. I have examined his material and the identification is correct. Sibthorp did not visit Egypt or Arabia, but the figure (*Fl. Gr.* t. 202) is certainly made from a living plant. Yet neither in his herbarium nor on the original of the plate is there anything to identify the plant definitely with Crete. We know that mistakes were made by Smith in the publication of the *Prodromus* and the *Flora Graeca* and it is strange that this conspicuous plant has not been collected since Sibthorp's time if it really does occur as a native in Crete. It is therefore best to ignore the species in the present connexion.

C. cantabrica L. Crete, Greece, Thessaly, Epirus, northern Albania, North Macedonia, South Macedonia, Athos, Thrace, North Bulgaria, South Bulgaria, Rodope, Dobruja, Serbia, Bosnia, Hercegovina, Dalmatia, South Croatia, Istria; with a general distribution from North, Central, and East Spain, through South and South-west France, Corsica, Italy, Sicily, the Maltese islands, Hungary, Slavonia, Croatia, Transylvania, Crimea, Asia Minor, Syria, Palestine, Caucasia to northern Persia. This is essentially a Mediterranean regional species which has locally extended outside the truly Mediterranean domain, especially to the north of the Balkan Peninsula. On the Age and Area hypothesis it is an old species in our area and I see no reason to dispute this.

C. dorycnium L. Crete, Attica, Aegina, Cilicia, Cyprus, Syria, Palestine, Persia, Transcaspia. This species, on an invasion hypothesis, must have come from the east or south-east. It is reasonable to suppose it must have reached Crete and the Greek mainland by the Tertiary land connexion and must therefore have had time to spread far in Greece. That it has not done so is inexplicable by the Age and Area hypothesis and I can suggest no possible barriers.

C. holosericeus Bieb. North Macedonia and northern Greece; with the general distribution: Crimea, Asia Minor, Syria, Iraq, and Armenia. This is most probably within the Balkan Peninsula a relict of a more continuous distribution. This conclusion is not favourable to Age and Area.

C. althaeoides L. Crete, Greece, Cyclades. The records for South Croatia and Istria are doubtful. The general distribution is Portugal, South, East, and Central Spain, southern France, Corsica, Sardinia, Italy, Sicily, the Maltese islands, Rhodes, Bithynia, Karpathos, Cyprus, Syria, Palestine, Iraq, Egypt, North Africa, and the Atlantic islands. This is another Mediterranean Regional species. It is difficult to see why it has not spread up the Adriatic coast and why on an Age and Area basis it has a less extensive distribution within the Balkan Penin-

sula than the next species. I do not consider that Age and Area aids us in understanding the distribution of this species.

C. elegantissimus Mill. Crete, Greece, Cyclades, Thessaly, Epirus, Corfu (?), Albania, North Macedonia (?), South Macedonia, Athos, Thrace, Hercegovina, Dalmatia, South Croatia, Istria; with the general distribution: Italy, Sicily, south-east Hungary, Mitylene, Pisidia, Smyrna, Bithynia, Troas, Lebanon, and North Africa. This is essentially an East Mediterranean Basin species, which north of the Balkan Peninsula has extended into Hungary. In our area it is essentially limited to the Mediterranean domain and there is evidently a climatic barrier to its general spread inland in the central districts. Yet it has extended farther in the Balkan Peninsula than has *C. althaeoides*, though I see no reason for supposing it to be older in our area than the latter which has a much wider general distribution.

C. tricolor L. Zacynthus, South Macedonia, eastern Thrace; with a general distribution: Portugal, Spain, Mentone, north-west Italy, Sicily, Lampedusa, north-west Africa. From the data available I conclude that the three stations for this plant may represent relicts of a formerly continuous distribution or may be new introductions. The species appeared to me to be wild on the hills of South Macedonia, but it is a common garden plant.

C. lineatus L. Greece, Strophades islands, west of the Peloponnese, southern Albania, North Macedonia (?), Dobruja. The general distribution is central, southern, and eastern Spain, South France, Italy, Sicily, southern and central Russia, Asia Minor, Syria, Iraq, Armenia, Caucasus, Persia, Afghanistan, Baluchistan, Waziristan, Egypt, North Africa, and Central Asia. The wide and, in part, discontinuous distribution of this species indicates it is an old one and that the Balkan Peninsular stations are of a relict nature. This is not in disagreement with Age and Area.

C. nitidus Boiss. Rodope (Ali-Botuš) and southern Spain. In the Balkan Peninsula this species is certainly a relict type and not a beginner in spite of its limited distribution. The same holds if the next species is united with it. The specific identity of the Spanish and Ali-Botuš plants is certain.

C. cochlearis Boiss. Attica: Pateras, Parnes. Northern Greece: Parnassus. North Macedonia: Mt. Ljubotin (verging towards *C. nitidus* Boiss.). The general distribution is not quite certain. I have seen one specimen from Cataonia and Boissier also records it from Phrygia and northern Syria. The affinity with the last species is very close and it may be that the two should be united. Together they represent a very old type in our flora, a conclusion which would not be reached on the basis of Age and Area alone.

C. radicosus Heldr. et Sart. Achaia: Mt. Kyllene, endemic. This is probably a high mountain derivative of *C. cantabrica* L., and if it is truly a species and not a mere habitat form, a matter that can only be settled by experiment, it is very probably of quite recent origin as would be postulated by Age and Area.

C. hirsutus Stev. Crete, Cyclades, eastern Greece, Thessaly, Corfu, South Macedonia, Athos, Thrace, North Bulgaria, South Bulgaria, Rodope, Serbia; with the general distribution: Crimea, Rhodes, Chios, Asia Minor, Syria, Palestine, Iraq. The extension of this species was certainly from the east, and though we must date it from the Tertiary, since it reaches across the Aegean to Greece and Crete, there is no reason to suppose it has reached its maximum distribution to the north-west. There is nothing antagonistic to Age and Area in the known facts for this species.

C. arvensis L. In every major district of the Balkan Peninsula and in general distribution practically cosmopolitan. On the Age and Area hypothesis its widespread distribution would make it an old species, as it may be.

C. siculus L. Crete, Greece, Cyclades; with the general distribution: Spain, South France, Corsica, Italy, Sardinia, Sicily, the Maltese islands, Cilicia, Cyprus, Palestine, Syria, Egypt, North Africa, Nubia, Atlantic islands. This is a Mediterranean Basin species and its limitation in the Balkan Peninsula is comparable to that of *C. oleaefolius* Desr. Not time, but a climatic barrier, such as greater rainfall or moisture, may be the cause of its restriction to the south-east.

C. pentapetaloides L. Greece, Cyclades, South Macedonia, Thrace; and outside our area, Spain, Balearics, Sardinia, Sicily, Italy, the Maltese islands, Rhodes, Troas, Lycia, Cilicia, Cyprus, Syria, Palestine. This is a Mediterranean Basin species which may have been introduced by man into South Macedonia and Thrace but whose limited distribution in the south of the Peninsula is difficult to explain on Age and Area.

C. pilosellaefolius Desr. Gallipoli Peninsula; with a general distribution: Armenia, Palestine, Syria, Iraq, Persia, Afghanistan, Turkestan, and Egypt. The one record may indicate a relatively recent extension of the species into the Balkan Peninsula, farther spreading not having occurred yet owing to lack of time.

C. mairei Hal. Phocis and Achaia, endemic. The affinity is with *C. arvensis*, from which, however, it is quite distinct. As would be postulated from Age to Area it may well be a relatively recent species.

Ignoring *C. lanatus* Vahl we may sum our results as follows: the distribution of ten species can be reasonably explained on the basis of Age and Area allowing for the action of known geological and meteoro-

logical factors, but the known facts of distribution of nine species are either opposed to the hypothesis or gain no explanation from it.

The genus Astragalus. The genus *Astragalus* has its centre of species development in the Orient, as the term is used by Boissier. Hence it may be regarded in general as eastern for the Balkan Peninsular flora. The general distribution of the non-endemic species and the affinities of the endemics support this view. Seventy species occur in our area, 31 of them being endemic and 39 extending beyond its limits. The average number of districts occupied by the endemics is 2·6, by the non-endemics 4·8. Thus, on the average, each endemic covers a much smaller area than each non-endemic. Moreover, only 2 endemics spread into 5 or more districts, while 13 non-endemics are recorded from 5 or more. The number of species occurring in 1, 2, 3, and up to 19 districts are 30/1 7/2 8/3 9/4 2/5 2/6 2/7 0/8 1/9 1/10 3/11 0/12 1/13 1/14 2/15 0/16 0/17 0/18 1/19, a series of figures which, expressed graphically, give a rather irregular hollow curve. These statistical facts agree with the Age and Area expectations.

Taking the 30 species limited each to one district only and placing them on taxonomic and phytogeographical grounds alone I consider 2 as relicts or old species, 4 as fairly old, 6 as fairly recent, 13 as recent, and the rest as very doubtful. On the whole the figures support the view that the majority of the local species and endemics of *Astragalus* are recent within the area. Fifteen of the 31 endemics occur in Greece, as might be expected if the chief invasion came due west from Asia Minor across the old Aegean continent. The evidence of a second invasion route can be traced into Thrace and Bulgaria.

The Primulaceae. The family *Primulaceae* in the Balkan Peninsular flora contains 52 species in 12 genera. The species are all herbs but differ widely in duration, life-form, habitats, altitudinal limits, flowering periods, Balkan Peninsular distribution, and general distribution.

Considering the 52 species individually the conclusion is reached that, with perhaps 3 or 4 exceptions, light is thrown on the relationship between their general and Balkan Peninsular distributions by the Age and Area hypothesis, when the geological facts and the division into Mediterranean and Central European climatic domains are kept in mind. The development *in situ* of *Cyclamen* within the Mediterranean domain, and a northern, high mountain invasion by *Androsace*, *Primula*, and *Soldanella* are clearly indicated and agree with the general taxonomic and phytogeographical conclusions. Most of the endemics have a narrow distribution, and many of the species with a wide general distribution have a wide distribution within the Balkan Peninsula. The correlation is not exact, but if the terms 'very wide', 'wide', 'limited', and 'very limited' are used as previously in this work

(p. 249) the results obtained for the two distributions of the Balkan Peninsular *Primulaceae* are:

General:	VW/11	W/4	L/25	VL/12
Balkan Peninsular:	VW/3	W/5	L/17	VL/24

Giving the values 4, 3, 2, 1 to each species in the respective groups the proportional area covered is represented by G : B.P. :: 118 : 85 or G : B.P. :: 1 : 0·7, instead of 1 : 1 with a complete correlation. It must be remembered that the Balkan Peninsular figure is likely to be increased in a greater proportion than the figure for general distribution as botanical exploration progresses. The discovery of several species in only one more district would move them into a higher category, and it is certain that such extensions of known range will be made. The distribution of the species as based on the number of districts in which they occur is 13/1 7/2 4/3 4/4 3/5 3/6 1/7 2/8 2/10 2/11 2/12 1/16 2/17 1/18 1/19 2/20 1/24 1/25. These figures graphically plotted form a somewhat irregular hollow curve.

Conclusions. The conclusions reached on the basis of these three examples are therefore in favour of the view that Age and Area sometimes yields conclusions of phytogeographical value in the study of the flora of a definite area or of the distribution of a particular genus or family. On the other hand, if used without constant reference to the balance of all known factors influencing the distribution of plants, it will, as will any statistical method, give misleading results. Three assumptions which have been made with regard to Age and Area do not hold for the flora of the Balkan Peninsula, and it may be that these are the reasons for my failure to use it as I at one time hoped I should be able to do. First, though in many, especially the larger, genera the young endemics (novitiate species) are more numerous than the relict, old, and fairly old species taken together, they do not swamp them. Secondly, there is no evidence that the factors limiting or otherwise modifying distribution cancel out in any group or groups compared with one another. Rather the reverse is true, and the means of dispersal, the limits of ecesis, and the degree of persistence in the phases of a sere profoundly modify the mechanical rate of spread postulated in Age and Area, and one has to seek for special influences in each group or at times in each species. Lastly, the available evidence is against the formation of species solely, or even mainly, by sudden mutations of single individuals. Both hybridization and hamagenesis, if at all widespread as modes of origin, would profoundly affect the Age and Area thesis, and the evidence is strong that both have played a not unimportant part in species formation in the Balkan Peninsula.

XVII

GENERAL CONCLUSIONS

As indicated in the introduction the main object of this work is a consideration of the phytogeography of the Balkan Peninsula *as a whole*. This has involved a considerable amount of analysis, but even in dealing with separate districts the unification of the work has been kept in view. The division into chapters, each concerned not with one district but with one aspect of the phytogeography of the whole area, was conceived for this end. It remains now to summarize the conclusions reached and to generalize on them.

THE RELATIVE PHYTOGEOGRAPHICAL IMPORTANCE OF THE EXTERNAL FACTORS.

1. **Physical features.** The position of the Balkan Peninsula, its proximity to Asia Minor, the mountainous or hilly nature of a large proportion of the area, the high mountain mass of the Rodope near the centre, the east to west orientation of the Stara Planina, the north-west to south-east or north to south orientation of the main western and southern mountain chains, and the possibility of penetrating inland from the coast up the larger river valleys and river plains are the most important of the physical features.

2. **Geology.** The most important geological facts bearing on our work are: the long connexion by an Aegean land-mass of the Balkan Peninsula with Asia, the formation of the Alps and the Dinaric system which first joined the Balkan Peninsula to Central Europe proper, the presence till later Tertiary times of the Sarmatic Sea or Pontic Lake to the immediate north of our area, the long existing pre-Tertiary land-mass of the Rodopes, the presence of many kinds of rocks, resulting in a diversity of edaphic conditions, the predominance of limestones in the south and west, and the relatively small degree of glaciation during the Ice Age of the higher parts of some of the mountains.

3. **Climate.** This, for different parts of the Balkan Peninsula depends largely on position, especially with reference to the sea, and on altitude, much less upon latitude alone. Climatic conditions are of wider importance than soil conditions in the botanical study of the Balkan Peninsula, and the climate, not the soil, must form the first basis for any proposed geobotanical subdivisions. Rainfall and temperature conditions vary greatly, and it is the seasonal distribution of the maxima and minima of each relative to those of the other that is of primary botanical importance. On this basis two main climatic and

corresponding floristic and vegetational domains are distinguishable, namely, the Mediterranean with maximum temperature and minimum rainfall in summer, and the Central European without a marked rainfall minimum, or with a minimum falling within the colder resting period, while the maximum rainfall tends to coincide with the season of increasing temperature. It follows that within the Mediterranean domain summer is not a period of active growth and development owing to drought conditions, for many species, indeed, it is more of a resting season for the vegetation than is the winter. In the Central European domain, on the contrary, growth continues through spring and summer, but the vegetation largely dies back in autumn for an almost complete cessation of growth during the winter. Between the two extremes of climate there is every possible gradation, but this does not alter the fact that these two types exist, and the most workable scheme is to correlate any given set of climatic conditions in our area with them. It may be noted that within the Balkan Peninsula the highest average summer temperature and the heaviest annual rainfall for all Europe are recorded.

OUTSTANDING FEATURES OF THE FLORA.

The flora of the Balkan Peninsula, with 6,530 accepted species, is richer than that of any other area of equal size in Europe. Not only is it prominent for the quantity of species but the number of endemics is likewise unique, and amongst these are many relicts of the Tertiary flora. A Mediterranean flora can be distinguished from a Central European one, each being typically associated with a corresponding set of vegetational communities and developed under the different climatic conditions outlined above. On the other hand individual species, or even small groups, of one of these floras frequently occur within the domain of the other, where local conditions permit of their successful competition with species belonging to the domain, though usually such outliers of distribution do not form marked communities, but occur relatively scattered amongst the species of the domain. Moreover, there are transitional areas showing all possible mixtures of species of the two floristic types, though most frequently there is a bias towards one or the other. The evidence available is in favour of a geologically recent extension of Mediterranean types and probably this is still continuing.

Various calculations of the total number of species in the world flora have been published. For the seed-bearing plants one of the latest is by Thonner, *The Flowering Plants of Africa* (1915), and it will be of interest to compare his figures with those I have obtained for the Balkan Peninsula.

	Whole Earth	*Balkan Peninsula*
Gymnospermae . . .	500= 0·34%	25= 0·4%
Monocotyledoneae . .	26,000=18%	1,040=15·9%
Dicotyledoneae . . .	118,000=81·6%	5,465=83·7%
Phanerogamae . . .	144,500	6,530

The percentages really show a remarkable agreement, though that of the *Monocotyledoneae* is slightly less for the Balkan Peninsular flora than for that of the whole earth and the *Dicotyledoneae* percentage correspondingly slightly higher. This result was somewhat unexpected, for the Mediterranean domain is frequently quoted as especially rich in monocotyledonous geophytes. It is evident that though terrestrial geophytic species of *Liliaceae*, *Iridaceae*, and *Orchidaceae* are a characteristic feature of the spring and early summer flora and vegetation of the Mediterranean districts of the Balkan Peninsula, they are insufficient in number to balance, even when estimated as percentages of the total flora, the large numbers of tropical and South Temperate species of *Monocotyledoneae*, many of which are not geophytic.

Sprague (*Brit. Assoc. Rep.* 1925, 363) has analysed 75 Phanerogamic floras and arranged the families in each according to the number of their species. He points out that the *Compositae*, *Leguminosae*, *Gramineae*, and *Cyperaceae* are high in most floras, while certain sets of other families, termed 'Indicator Families', are high only in particular types of flora. On this basis the Balkan Peninsular flora is North Temperate, since the 'Indicator Families' chosen by Sprague for this category [1] are all high in species numbers in our flora, although they are not dominant in the order given by him. In the Balkan Peninsular flora the *Ranunculaceae* come tenth, the *Rosaceae* eleventh, the *Cruciferae* sixth, the *Caryophyllaceae* third, and the *Umbelliferae* seventh in number of species. The total species represented in these families in the Balkan Peninsula is 1,207 or 18·4 per cent. of the whole Phanerogamic flora. In addition to the families mentioned above the following stand high in species numbers: *Labiatae*, *Scrophulariaceae*, *Liliaceae*, *Borraginaceae*, *Campanulaceae*, and *Rubiaceae*. It may be noted that all the twenty-one largest families and all the twenty largest genera are entirely or predominantly herbaceous or suffruticose.

OUTSTANDING FEATURES OF THE VEGETATION.

As we recognize two types of flora so we recognize two main types of vegetation in the Balkan Peninsula—the Mediterranean and the Central European. The former have the predominating species xeromorphic

[1] "2. *North Temperate* (incl. Arctic and Subantarctic): *Ranunculaceae*, *Rosaceae*, *Cruciferae*, *Caryophyllaceae*, and *Umbelliferae* forming 12–25 per cent., and in the first 9–19 families."

in structure or with a life-history otherwise adapted to surviving the summer drought. The latter are essentially composed of mesophytic species whose life-history has its resting phase in winter. The characteristic communities of the Mediterranean domain are, in the lower zones, open sclerophyllous evergreen woods, macchie, phrygana, and rock vegetation; while at higher altitudes, where the summer drought is less extreme and the winter cold greater, deciduous communities may occur approximating to those of the Central European domain. The characteristic vegetation communities of the latter are: oak, beech, and conifer forests, deciduous brushwood (shiblyak), high mountain heaths, steppe-like grassland, stony heaths, and open rock vegetation. The maritime, aquatic, and marsh communities are not essentially different, floristically or ecologically, in the two domains.

Although climate is the most important factor in the distribution of the different vegetation communities within our area it is difficult to over-emphasize the modifying influence of man. This has been dealt with as completely as space allows in Chapter X, and all the lines of evidence, historical, ecological, and floristic, lead to the same conclusion, that especially by forest destruction man has induced enormous changes in the flora and vegetation of the Balkan Peninsula. It is proved that the forest areas have become, and are becoming, more and more restricted. Brushwoods, 'heaths', stony 'grassland', and rock communities occupy much ground which should, under the existing climatic conditions, be covered with high forest. This means that species suited to such habitats have been given opportunities for extending their distributional areas. Many, in utilizing these opportunities, have come into contact with fresh species capable of crossing with them and considerable hybridization has resulted. By extending their ranges and by increasing the number of their individuals species are the more likely to give rise to new species, by any of the recognized methods of evolution. Hence those genera, predominantly herbaceous or suffruticose, especially characteristic of the vegetation of deforested habitats in the Balkan Peninsula are frequently represented by very many species, a high percentage of which are endemic, and probably recent, while others represent the old parental types. Examples are *Centaurea*, *Verbascum*, *Silene*, *Dianthus*, *Thymus*, and *Astragalus*. The habitat figures as well as field studies and travel within the area very clearly demonstrate the predominating importance of the same habitats. In tracing the history of the flora and the geological succession of the vegetation it is essential to make allowance for the above facts. Hence the importance of study and collecting in the least disturbed parts of the Peninsula and the urgent need that this shall be accomplished before the natural vegetation is further destroyed or modified

by man's exploitation. Thorough exploration of such areas as the Rodope massif and Strandja Planina is phytogeographically as important as, and decidedly more urgent than, that of western China or tropical Africa.

HISTORY OF THE FLORA AND VEGETATION.

In attempting to outline the evolution of the flora and vegetation of the Balkan Peninsula one is considerably handicapped by the few reliable accounts of fossil plants from the area. The published papers on this subject can only be considered as indicating that the flora of the early and middle Tertiary was very similar to that of the rest of Europe, and perhaps of the whole North Temperate Region, during those times; and further, that the species and often the genera were, on the whole, different from those in the existing flora. In other words there has been much change in the floristic composition, and probably also in the nature of the vegetation. The change has been of a twofold nature; species and genera have disappeared from the area and others have appeared in it. That some have become really extinct is certain, that others have become extinct in the area but still exist elsewhere may be considered probable. We may note, however, that the Balkan Peninsula has a considerable number of relict species and types certainly dating from Tertiary times, and in this sense is the most important European 'area of refuge'. There is no continuous impassable barrier separating Central Europe from the Balkan Peninsula. In other longitudes species were 'driven up against' the Pyrenees, the Alps, or the Mediterranean. Regarding the appearance of fresh species and genera we have to distinguish origin *in situ* from immigration, in the sense of distribution advancing into the Balkan Peninsula. The former is a sort of static development of the flora, the latter an infiltration of elements from outside. I have several times urged, in the present work and elsewhere, the importance of the Balkan Peninsula as a centre of species making and dispersal and this applies especially to the ancient land-mass, the old core of the Peninsula, centred in the Rodope massif. On the other hand, it is certain that development *in situ* only explains the history of a part of our flora; even if one accepts hamagenesis as having occurred in some genera the evidence is conclusive that extension and contraction of distribution must also be accepted. Immigration, re-immigration, and extension of area are very definitely known to have occurred in northern Europe after the Ice Age. The Ice Age had a much smaller influence on the Balkan Peninsular flora than on that of northern Europe, with the result that the botanical history of the former has been less dynamic, and decidedly less catastrophic, than that of the latter. Nevertheless,

extensions of specific distributions have certainly occurred from the Balkan Peninsula northwards to the areas of the former Sarmatic and Pontic waters, and a westward extension fits the phytogeographical and geological facts for the known distribution of so many species, that it seems impossible to avoid accepting natural 'migration' of species as one cause of change in our flora. The history of the flora has been a complex one and many fluctuating factors have been concerned in its present composition.

It is unnecessary here to enter into a general discussion regarding species. Some of my views on the subject were published in the *Journal of Botany*, lxiii. 359 (1925). It will suffice to point out that my phytogeographical studies on the Balkan Peninsula have clearly indicated that no one of the hitherto suggested methods of species formation is sufficient to account for all the facts, and that nothing has appeared antagonistic to the view stated in the above paper that species, as accepted in practice by the majority of taxonomists, have originated in various ways. In referring to individual genera it has been pointed out that sometimes one, sometimes another of the evolutionary theories best fits the known facts. Certainly hybridization and mutation seem to have occurred frequently and to have resulted in differences to which taxonomic value is accorded. The working of natural selection can reasonably be postulated in our area with its wide range of climatic conditions, while the direct action of the environment may well account for the origin *in situ* of many of those high mountain plants which have close relatives in the lowlands, a phenomenon of which many examples are known, especially in Greece. Undoubtedly a large proportion of the needed theoretical explanation is afforded by a combination of hybridization and fractional mutation, whether *en masse* or of individuals. The change *en masse*, with an underlying supposition that this is correlated with climatic changes, is supported by Stefanoff in his studies on *Colchicum* and on the phytogeography of the Rodope massif. He has used the term 'syngenesis' for this theory, although this has also been used in biology for a totally different phenomenon. I have, therefore, suggested the term 'hamagenesis'. Saporta (*L'Évolution du Règne Végétale*, ii. 205, 1885), postulating from fossil plants that a species might be 'cantonné' and so give rise to a successional series of species, appears to mean a similar process of evolution. Such a process alone cannot explain all the phytogeographical facts which have emerged in the course of the present work. We accept then, as the basis for the study of the history of the flora, that extinction within, species making by various methods within, and extension into, within, and from the Balkan Peninsula have all been, and probably still are, active.

In Eocene and Oligocene times the Balkan Peninsula was joined to Asia, and, except for the possible Carpathian bridge, was separate from Central Europe. The flora was predominantly of a different composition from that of the present day, and many of its genera and most of its species are now extinct in our area. Nevertheless an important number of the existing genera were already present, and, without accepting the specific identifications of the fossils, it seems certain that *Acer*, *Alnus*, *Carpinus*, *Corylus*, *Fagus*, *Laurus*, *Quercus*, *Salix*, *Celastrus*, *Prunus*, *Myrtus*, *Olea*, *Cercis*, *Diospyros*, *Ficus*, *Juglans*, *Platanus*, *Populus*, *Rhus*, *Styrax*, and *Zizyphus* were represented, in addition to various conifers. In this sense, then, and with special reference to the woody genera, it is correct to say that the flora has its roots in the old Tertiary period. It is most probable that many other, even herbaceous, genera, and perhaps even some species, of the existing flora were also represented in the area even so far back as the Eocene. On this subject we have some indirect evidence in Tertiary relicts judged as such on distributional and taxonomic grounds but of which fossil remains have not yet been discovered. It is, however, impossible to be sure how far back in the Tertiary these may date. It is very probable that there was an important, perhaps dominant, warm temperate to subtropical element, which has become extinct, or almost so, in the area. The published records are sufficient to justify this statement, although many of the identifications are doubtful. The facts available are quite insufficient to draw conclusions as to floristic differences in different parts of the Balkan Peninsula at this time and we know nothing of altitudinal zonation. The connexion with Asia Minor and one with North Africa would enable the flora of the eastern Mediterranean area to attain almost complete uniformity, associated with the general floristic uniformity in early Tertiary times from the Pyrenees to the Himalayas.

In Miocene and Pliocene times the linking of the Balkan Peninsula to Europe was accomplished, first by the Alpine system of folded mountains, and finally by the drying up of the Sarmatic sea and Pontic lake to the immediate north. So far as the existing lowland and hill floras are concerned this has probably been of greater importance for the Central European than for the Balkan Peninsular flora. That is to say more species have extended from the Peninsula northward than have extended southward into it. The reverse is, however, true for the high mountain flora. It is clear that the great majority of high mountain species of essentially Alpine distribution occurring in the Balkan Peninsula have come from the Alps or Carpathians into our area, and have not first entered the Central European mountains from the south. This important connexion of the high mountain floras

must date from early Tertiary times though it was doubtlessly intensified during the Ice Age. In addition to the incoming of Alpine plants the beginning of autochthonous formation of many of the high mountain endemics must date from the middle and early Tertiary. It is very clear, especially for the southern districts of our area, that many species limited to one or to several mountains have originated from more widely spread hill or lowland species. It is reasonable to assume that this differentiation commenced with the elevation of the mountains and the final result may have been due to selection or to direct action of the changing conditions, the new characters appearing either in single individuals or in masses of the population. It is probable that during the Pliocene period the general vegetation of large parts of the Balkan Peninsula was very like that of some few parts of the existing vegetation where man has not interfered. Forests were widespread, except in some of the southern marshy plains. Conifers were more dominant than now, and the Mediterranean domain occupied a narrower area and its northern limit lay farther south. Such forests as those in the Rila Valley, the *Fagus orientalis–Juglans regia* forest, we discovered in the southern Rodope massif in 1926, and the forests of the Strandja probably give a good idea of the Pliocene forests of much of the central part of the Balkan Peninsula.

At the end of the Pliocene the coming of the Ice Age affected North and Central Europe in a drastic manner. The Balkan Peninsula did not completely escape climatic changes but the actual glaciation was extremely local, being limited to some of the highest mountains. It is difficult to estimate the amount of change in temperature and rainfall. That the former was much lower in each season than in Tertiary times and lower than at present must be regarded as certain. The evidence regarding rainfall is indirect, but indicates that during or towards the end of the Ice Age the rainfall was generally, or at least seasonally, heavier than at present in parts of the Balkan Peninsula. Many of the river valleys and diluvial deposits must have needed greater volumes of water for their formation than are historically recorded. This statement, as based on my own observations, applies especially to the central parts of the Balkan Peninsula, though there is much evidence in favour of a 'Diluvial Period' over a wide area of the eastern Mediterranean area. The phytogeographical evidence is in favour of a southern extension of a Central European type of climate about this time, and associated with this the high mountains would have a more Alpine climate than they had previously or have now. An increased immigration from the north, and especially the north-west, of high mountain Alpine and Carpathian plants at this period explains the preponderance of these in the west and centre of the Balkan Peninsula. Their great

diminution south of northern Albania suggests a limit for the most important temperature effects of the Ice Age in this direction. The most reliable geological data support this conclusion. It is improbable that even in the north-western districts of the Balkan Peninsula (Illyria) the Mediterranean flora was entirely destroyed during the Ice Age. It was certainly reduced and its vegetation zone was narrowed. Attention has been called to the unexpectedly slight connexion, excepting the widespread Mediterranean species, between the floras of much of North Africa and the Balkan Peninsula. This is in great contrast with the close floristic connexions between Spain and north-west Africa. In Tertiary times the floras were probably much more alike than they are now and the differences became marked with the passing away of the Diluvial Period, coincident with or immediately succeeding the Ice Age of northern and Central Europe. Further, these differences were due much more to drastic floristic changes in North Africa than in the Balkan Peninsula. The evidence suggests that with the passing of the Diluvial period North Africa became drier, and a more xeromorphic desert type of flora took the place of the Mediterranean flora, which now began to extend northward. Thus we have as a working hypothesis the conclusion that the Ice Age, with its associated Diluvial Period, caused in the eastern Mediterranean at its oncoming a considerable extinction of Tertiary species, some of which, however, survived as relicts in the Balkan Peninsula and elsewhere; at its maximum a pressing southward of the Central European, Alpine, and Mediterranean floras and a possible narrowing of the latitudinal extension of the last, unless much of the Sahara area was then 'Mediterranean'; at its ending a northern extension of the Mediterranean flora and, in North Africa, the appearance, in places right to the coast, of the desert flora, with the extinction here of many types previously common to both sides of the Mediterranean.

Throughout Tertiary and up to the beginning of Quaternary times the Aegean area remained as a land connexion between Europe and Asia. The shattering of this connexion, while not completely preventing, certainly considerably reduced east and west migrations. Hence we conclude that the majority of floristic similarities between Asia Minor and the southern districts of the Balkan Peninsula date from before late Tertiary or very early Quaternary times.

During post-glacial times it is probable that the Mediterranean flora has penetrated inland and northwards. That is, with the return of warmer and somewhat drier conditions it has successfully competed over a wider area with the Central European vegetation. There is a wide range of evidence, which is outside the scope of this work, in favour of a similar view for much of Europe, evidence which even involves

western Europe as far north as south-east Sweden and the British Isles. In historical times this extension of Mediterranean types has been considerably aided in the Balkan Peninsula by the action of man in deforestation and of his flocks and herds in preventing tree rejuvenation. Large areas of former forest have been changed into dry stony and rocky habitats for which many Mediterranean plants are eminently suited by their xeromorphism. This extension of the Mediterranean flora is still proceeding without any indications of great climatic changes since classical times.

The brief sketch given above, although far from a complete history of the flora of the Balkan Peninsula, is, I believe, as far as we can go with reasonable certainty at present. Some authors have attempted a more detailed account, but the result has been many pages of inaccurate, irrelevant, or at least unwarranted statements merely to avoid the confession that many episodes remain entirely unknown to us.

ADDENDA

Page 103. For the neighbourhood of Sofia, Stoyanoff has shown [*Mitt. Bulg. Bot. Ges.* ii. 105 (1928)] that, treated statistically, the flowering periods of the less highly organized plants (i.e. those without perianths or with free sepals and petals or with free petals) are correlated with precipitation and temperature. The maximum flowering of these species coincides with good precipitation and mild temperature. The flowering of the higher plants is especially correlated with precipitation, the gamopetalous species and those with flowers in heads reaching their maximum flowering as the monthly precipitation decreases in late summer. In spite of many exceptions it appears that, on the whole, the species of the Sofia basin belonging to the more highly organized families have their flowers and fruits better protected against extremes of temperature and drought than those of the more simply organized families.

Page 133. A few supplementary remarks may be added about the interesting *Quercus aegilops* L., which is not common in cultivation in the British Isles. It is placed in the same section (*Cerris*) as *Quercus macedonica* DC. and *Q. cerris* L. In the Balkan Peninsula, in good moist soil, it attains to 26 m. in height, but rarely reaches to more than 10 or 15 m. in dry situations. The leaves are usually deciduous late in the autumn, though they remain green longer than those of other deciduous oaks (excepting *Q. macedonica*) and sometimes persist till the next spring. The blades are coriaceous, the upper surface more or less shining and provided with a short stellate pubescence, and the lower with a grey tomentum. The young shoots also have a greyish tomentum which persists in the second year. The species is abundant in Greece and the adjoining islands, either as solitary trees or forming woods. It flourishes equally well on a variety of soils. A well-known forest in Elis grows in a plain on rich loam, where myrtle, arbutus, and lentisk are found in profusion. In Acarnania and Aetolia the trees grow on rocky hill-sides. In Elis and Achaia the yellow-berried parasite *Loranthus europaeus* Jacq. is found on every second tree. The species is essentially one of the lowlands and rarely goes far up into the hills. It is not cultivated in the ordinary sense, but existing woods have been protected for the value of their cups as tanning material. The large acorns are sweeter in taste than those of other species of oak, and are eaten, either roasted or raw, by the inhabitants. They are slightly astringent and have a nutty flavour.

Page 340. B. Stefanoff has published an important work on the origin and development of the vegetation types in the Rodopes (*Proizchozdenie i razvitie na beletacionnite tipove be Rodopite*, Sofia, 1927). The work consists of 205 pages and nine maps. It is too long to summarize here, but it is very desirable that attention be called to it. The author especially attempts to correlate the present regional distribution of the vegetation of eastern Europe with a progressive 'continentalization' of the climate. A direct adaptation of the plant life is postulated to have followed this. An interesting fact is pointed out, namely, that the botanical connexion between the Rodopes and the Oriental mountains is not direct for many species, but is through the mountains of central and southern Macedonia.

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THE BALKAN PENINSULA

Kilometres
0 20 40 60 80 100

Existing political boundaries------

For districts as used in this work see chapter I and accompanying map in the text

PETER ROBERSON

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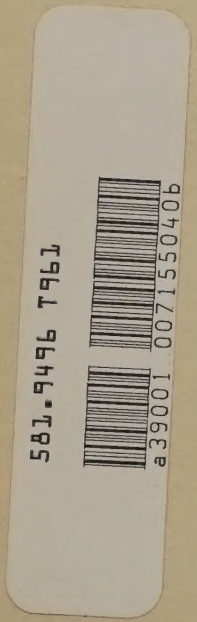

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